THE FUTURE OF THE U.S. SPACE PROGRAM

HEARING

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

JULY 23, 1990

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THE FUTURE OF THE U.S. SPACE PROGRAM

MONDAY, JULY 23, 1990

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, D.C.

The Subcommittee met, pursuant to call, at 9:02 a.m. in the St. Louis Science Center, St. Louis, Missouri, Hon. Harold L. Volkmer presiding.

Mr. Volkmer. The Subcommittee on Space Science and Applications will come to order. I am pleased to convene this public hearing today in my home state and on a topic of vital importance to the City of St. Louis and the State of Missouri.

And to vary just a little bit from my opening statement, it was just about six years ago, if I remember right, that I had another hearing in this very same room by this Subcommittee and we discussed some of the—at that time, futures of the space program, and the two first witnesses will remember the material processing in space and those type of things. So the future of the U.S. space program has occupied a prominent position on our nation's agenda for the past 30 years and formed a very important part of our heritage.

Today, we intend to examine the long range trends and forces that will dominate our progress in space over the next several decades. There is no question that NASA has ambitious vision of human exploration of the moon and Mars and expanded science effort and a permanently manned space station by the year 2000. During the same period, we will see the private sector begin to enter the space arena in earnest. Space activities such as satellite launching by expendable launch vehicles will generate an industry that will become a basic part of our economy. Other areas of space commercialization such as material processing in space and protein crystal growth hold great promise for our future and our quality of life.

As we hold this hearing, let us also be aware that space is now an international activity. The Soviet Union, Europe and the Pacific rim nations all have similar aspirations in space. They will challenge us both technologically and economically in every area. We certainly must cooperate where it makes sense and compete where we must.

Finally, I must regrettably recognize that our industrial base that supports our civil space program is undergoing substantial changes and in transition. The recent downturn in the aerospace industry and reported layoffs could very much affect our ability to sustain a high quality space program. An expanded space effort, such as we will be discussing today, certainly offers a way to refocus our resources in this area. I would appreciate any views our witnesses may have on how we can go about doing this.

So today, I look forward to welcoming our panels of distinguished witnesses. I look forward to your testimony.

At this time, I would like to recognize my colleague and good friend from Missouri, who I not only served in previous times in the General Assembly and on the same committee and now on the same committee in the United States Congress, the Honorable Jack Buechner.

Mr. BUECHNER. Mr. Chairman, I would like to thank you and our other distinguished colleague from Louisiana who belongs to the Subcommittee on Space Science and Applications for coming to St. Louis to hold this hearing on the future of the United States' commercial space program. From a national perspective, the space program has been a consistent source of pride and hope. It challenges us on a daily basis to improve upon our best technology, but to the people of this area, it is much more than that. A substantial segment of our local economy, as you pointed out, is predicated on the aerospace industry and that industry has long been defense-oriented. As democratic reforms and peace sweep the globe, we would have to be cognizant of the fact that people and corporations in this area, and others like it, can hopefully redirect a substantial portion of their efforts to the conquest of space.

I would like to thank all of the witness who have agreed to testify at this hearing. We are most fortunate to have all of your experience and expertise at our disposal. And of course, I would like to thank the people of this area for their interest and their commitment to the success of our space program.

Today, we are going to be hearing testimony regarding spin-off technology, the expendable launch program and the need for science education. Each of the topics will be essential for the future of our space program. Spin-off technology enhances the value of the space program by applying that technology to other fields. It makes our life better. Just take a look at the kangaroo exhibit that is our here and you will understand that out of something like moon boots, you can have a tremendous job creation program.

ELVs will minimize the risk to human life and help prevent the sort of disaster which would cripple the space program.

And finally, we are going to hear testimony regarding the future of science education, which well may be the most important element in shaping the future of all science related programs and our space program in particular.

Mr. Chairman, there is one thing that I would like to emphasize to the people in attendance today and I am sure all of our witnesses will agree with me; the space program is not about astronauts or scientists or NASA or even congressmen on the authorizing committee. The space program is about America and its people, our national pride and ambition. In short, the space program can only be what the American people want it to be—no more, no less. With your help and your support, the possibilities are endless.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you.

At this time, I will recognize our colleague—who has taken time off to be here, from Louisiana, the Honorable Jimmy Hayes.

Mr. **Hayes**. Thank you. The way things are going in Louisiana, it is my privilege and pleasure to be almost anywhere but there.

[Laughter.]

Mr. **Hayes**. I am actually not here for the hearing, I am here to endorse the Jack Buechner re-election campaign.

[Laughter.]

Mr. **Hayes**. You may find that strange for a democrat to do but I thought to myself, in 1990 what would most help the Democratic party and I thought having more Republicans like Jack Buechner.

[Laughter.]

Mr. **Hayes**. So, I am here to urge everyone in St. Louis to please keep sending him back.

[Laughter.]

Mr. **Hayes**. He is my next door neighbor in the Cannon Building. It used to be an attic and it is now converted into hall space for us. As you can imagine, that puts us in day-to-day proximity and for that reason, he knows so much about me that he can get me to show up almost anywhere at any time.

[Laughter.]

Mr. **Hayes**. I look forward to the hearing. If our Chairman were here, Bob Roe, the Chairman of the full committee, he would say in a much longer version, the new wealth. What he means by that is that in the advancement of the sciences and the application to commercial products and the transfer of technology, the nations that best understand the application of scientific achievement in the marketplace control the new wealth for the 1990s. He is confident that the people of the United States will support this committee and the effort of their elected officials and public servants to recognize that what we are doing is not merely promoting a part of a scientific achievement program but competing with the rest of the globe in order to create the product lines that at this moment do not exist but which will mean the difference between an enhanced economy and one that falls into the rank and file of global participation. So for that reason, I am pleased to be in St. Louis. I look forward to the hearing and will not drag it out any longer because we are probably going to have to leave early to beat the weather back to Washington.

Thank you again, Jack, for inviting me and Harold for chairing.

Mr. **Volkmer**. Thank you very much, Jimmy. I appreciate your coming. I was going to say that we will adjourn this hearing promptly at eleven o'clock, if not before, due to the fact that we are in session this afternoon in the Congress and we are to have votes starting at three o'clock. The other thing that is occurring is that we have the possibility of thunderstorms in the Washington, D.C. area sometime this afternoon. We are checking that out because we are going to have to land in order to get to the votes. We cannot vote from up in the airplane flying around.

The other thing that I would like to mention is something that Congressman Buechner has mentioned, these spin-offs. I know that one of our witnesses—the first witnesses, will address that. As I understand, the Kangaroo Shoe Company does have an exhibit here at the Planetarium. Afterwards, if you wish to examine it, that is a spin-off from the space effort, one of many.

At this time, I would like to recognize our first two panels. The first panel is Mr. Charles Walker from McDonnell Douglas Corporation, an old friend, one of the first civilians in space with the electrophoresis operation from McDonnell Douglas and one who has worked hard on our space program for a good many years. Also, Mr. Jim Rose, who I consider a friend, who is now with NASA and before was also one of those when I was back here years ago and they were in the embryo stages on the electrophoresis materials processing. He took me through the operation down at McDonnell Douglas and explained it all to me and he had the foresight at that time to see that materials processing is one of the areas in which we can have a lot of future in space.

At this time, I would like to first recognize Mr. Rose to lead off.

STATEMENTS OF JAMES T. ROSE, ASSISTANT ADMINISTRATOR, OFFICE OF COMMERCIAL PROGRAMS NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND CHARLES WALKER, MCDONNELL DOUGLAS CORPORATION

Mr. ROSE. Thank you, Mr. Chairman, and members of the Subcommittee. I am very pleased to be here today and I would like to submit my written statement for the record and briefly summarize it here.

Mr. VOLKMER. All written statements will be made a part of the record at the point at which the witness testifies. You may either review that in full or summarize, however you so desire.

Mr. ROSE. Thank you, sir.

All of us in the United States are aware of the economic competitiveness that we face from Europe and Japan. Competitiveness is a word that we are all becoming familiar with. Our future, I believe, will be significantly influenced by how well we continue to compete in areas of high technology, not just developing it first, but applying it first.

Space is a high technology focus. By actively supporting the transfer of space solving technologies to producing new and improved products on earth by the private sector, we are strengthening our nation's competitive position. By pro-actively encouraging industry to pursue opportunities in space itself offers the developing of new products and services for this nation. I believe we have the opportunity of gaining the lion's share of this new space economic frontier.

First, has space technology transfer contributed to our economic well-being? It has been estimated that over 20,000 applications by the private sector has been made for commercial purposes by using technologies initially developed to carry out our space missions.

First chart, please. As you will see on the screen—I think it is in your handout. Unfortunately, you will have to look up. This is just a small smattering of down-to-earth products that could carry a space derived label. Now I suspect that everyone in this room can look down that list and will find things that they are familiar with. Such as cordless tools; such as the athletic shoes that were mentioned earlier, scratch-resistant lenses for sunglasses. You know, the list goes on.

In a recent study, 259 such product manufacturers were willing to provide economic figures for the contributions space technology made to sales and savings between 1978 and 1986. That is an eight year time period. Twenty-one point three billion dollars towards sales and 315 million towards savings were identified. From these figures it is estimated that 356 million in corporate income taxes were paid and 352,000 jobs were created or saved. That is just 259 of some literally tens of thousands of applications.

Now on a broader scale, a study by the Midwest Research Institute in Kansas City estimated that from 1960 to 1986, almost the total length of the space program, at least $1.3 trillion was added to the U.S. economy on a 148 billion NASA R&D investment during that time frame. That this technology spin-off would continue to pay off through the year 2004 with discounted rates of return estimated between 19 and 35 percent. Now any business, any stockholder of any business, would be excited about the prospects of getting 19 to 35 percent internal rate of return. That is compounded interest from the day each dollar was invested. The space program today provides a needed focus for high technology development within this country. The technologies to support the tens of thousands of current applications could not have been developed individually as the cost would have been both prohibitive and the concept of ideas would have been very sporadic.

In today's environment, space does play a vital role in keeping us economically competitive, not only in aerospace, but in every field of private enterprise. Whether we choose to go the moon, back to Mars or wherever, the focus of that technology is going to create significant applications and significant economic growth for this country.

How does NASA transfer technology? We have an active program. We were one of the first government agencies—and, I guess, the only one for awhile—that actually had an active transfer program. At all of NASA's nine centers, an office is dedicated to ensuring that the technologies being developed by NASA and its subcontractors are being reported. A publication called TECH BRIEFS provides information on new NASA research innovations and is distributed monthly to approximately 200,000 members of U.S. industry.

Repositories in Baltimore, Maryland and Athens, Georgia maintain active files of all accumulated technology and software programs. NASA's network of ten industrial application centers is the key component of the technology dissemination system. These industrial application centers cultivate strong ties with industry, identify client problems and interests and assist through the exchange of technology information by direct access to the NASA repositories.

The industrial application centers are backed by a score of affiliates, which are state-sponsored business and technological centers. Through the industrial application centers, the affiliates are provided access to the NASA database. This complete network now resides in 41 of our 50 states. The technology search program at the University of Missouri in Rolla is the affiliate here in Missouri. We call this program Technology Push. We also have a Technology Pull activity.

Technology applications are accomplished through interactions with public and private sectors of the economy to identify specific needs and problems and develop potential solutions through additional adaptation of space-developed technologies. Some 500 jointly sponsored projects have been carried out to date. There are some 73 projects currently in progress.

Some notable examples of applications projects include the rechargeable-reprogrammable pacemaker; the modern breathing system most firefighters today use in this country; the hazardous gas detector most commonly used by the industry. In Missouri, the Central Institute for the Deaf at Washington University has been working on a NASA applications project that uses new digital technology to develop an improved hearing aid device.

Switching now to the commercial development of space itself, how can the government help our private sector compete against foreign firms receiving direct or indirect government support in the commercial development of space? To this end, NASA and the DOD have become customers of McDonnell Douglas' Delta, General Dynamics' Atlas Centaur and Martin Marietta's Titan launch vehicles.

Now this helps in the near-term, but is woefully inadequate as we look to the future. What my launch vehicle colleagues, which you will be hearing from in the next panel, need are many more private customers if true commercialization of space is to really become a reality. Initiatives which are geared to serve private markets and which will be developed by private investments are five times more effective in expanding our nation's economy than initiatives which rely on the public sector as the investor and user. Private markets and products must be developed in new areas of communication, remote sensing and micro-gravity.

Therefore, our strategy at NASA is very simple. First, to assist the private sector in establishing the technology and development base that can lead to new products and markets and second, to help establish the infrastructure and transportation industries which can directly contribute to the creation of these product markets.

As products and markets mature, the necessary infrastructure and transportation will be available to support the transition into commercial operations. Now we must certainly remember that it will not be the government that commercializes space, but it will be private industry itself. Therefore, how we implement government help to the private sector is just as important as the help itself.

Issues concerning confidentiality of data, protection of intellectual property and risk management can jeopardize the success of cooperative ventures.

We believe we have developed a program through which the government can continue to meet its public responsibility while avoiding the tendency to direct control and oversee the commercial initiatives to be worked out in joint collaboration.

First, if we are going to develop private markets or help the industry develop private markets, we must get the non-aerospace industries thinking about space seriously. Industries like duPont, Amoco, Merck, Monsanto or Mallinckrodt. How do we get companies like this involved?

Well we chose a mechanism we call Centers for the Commercial Development of Space. These centers are consortia of university or not-for-profit institutions and commercial companies working together in focused areas of research that is industry-driven. It is the areas that industry believes could have potential application in their company. By focusing our technologies in this field, working with the industries, as we begin to learn what you can do in space that is different from the ground, hopefully new applications will emerge.

What we ask these centers that we created, and we have 16 of them, to do—first, could they lever a broad industry base to develop product-oriented technologies. And secondly, could they stimulate commercially cost-effective transportation and infrastructure ventures.

Yes, I think they are doing that and we are very pleased with the progress we have made so far. As I said, we have 16 of these consortia, five working in materials processing, two working in remote sensing, three working in life sciences or biomedicine as I prefer to call it, two in space power, one in space propulsion, two in automation and robotics and one in major structures. All of these are working in focused areas that could lead to private products developed by the private sector that could then be used to drive private transportation and private infrastructure.

We now have 193 companies working in support of these 16 centers. You are not supposed to read this, you are supposed to be impressed by the fact that there are a lot of companies now actively involved in this program. And that is what you wanted, a statistically large sampling of American industry looking seriously at space as a place to perhaps do work.

In addition, what is also important, there are 57 universities now working in support of these centers. What is happening is where expertise resides in different universities, they are joining the center working in that particular focus. So we are beginning to get the best minds in the United States focused in specific areas of interest to the industry partners that are involved.

What are other measurements of success? Is industry contributing? Since this is a levered affair, we put money in in a grant form, is industry contributing? Yes, industry is.

When we first started the program, NASA's contribution to keeping these centers active was approximately 80 percent of that cost and industry's contribution of dollars and in-kind services was 20 percent. Today, industry is now putting 70 percent to NASA's 30 percent. And in the original five centers that have the longest time period, industry's contribution is almost four dollars to every one that we are putting in. And that is important. If industry is contributing, then they are interested, and they will not casually walk way from a technology without first truly understanding it does not have any further activity to carry it further.

Other measurements, eighteen patents have already approved and 41 are pending. Patents are important. Some 800 publications have been made to date in reference journals and 91 are in the works. More importantly, five spin-off companies are already being established to generate new revenues and new businesses as a result of the work in these particular centers.

They have created 61 areas of technology that they feel, through their ground base work, has potential and therefore we should look at space because they think space will make a difference. Within these 61 areas of technology, we are now carrying out an aggressive flight-test program to mature these technologies to a point that the industry partners can make a decision that says there is something to be done with this technology or not. If they can make the decision that there is something to be done with it, they will then move it into a development program which ultimately we hope leads into a truly commercial application.

In order to carry out such an ambitious flight program, we need some 300 flight tests to be carried out between now and 1995, and these flight tests will use not only the Shuttle and the Shuttle middeck, which is customary for this type of payload, but we are also now leasing a commercially developed carrier that will be flying in the Shuttle, called Space Hab. We are negotiating for that. Some 84 flight tests will be carried out on that particular carrier.

In addition, we have already created an expendable launch vehicle program and what we are doing there is allowing these commercial centers to contract for their own sounding rocket. Which means they are using commercial practices, commercial specs, everything that is needed to make commercialization a reality. In addition, we have identified some 23 flight tests that need extended time in orbit and quiescent time, and to that end we are beginning the process of developing a small expendable launch vehicle and recovery system program using the same methods of allowing these centers to develop them.

Now this is our approach to getting the infrastructure and transportation world involved in supporting the developing technologies that will lead to products. A real space industry consists of products and markets, transportation and infrastructure, and if we can allow them to develop in a natural way and mature, we will have established the type of underpinning that true commercial space will require.

Now this is not going to happen overnight because you have to start at the beginning, you have to start at the technology phase. But we are confident that if we continue to pursue this program, we have the ingredients and the mechanisms established to make it happen. So we are enthusiastic at NASA, we think the program is working, and we are looking to many successes in the years to come and I hope I will have an opportunity to tell you about them next year.

Thank you, sir.

[The prepared statement of Mr. Rose follows:]

NASA
National Aeronautics and
Space Administration

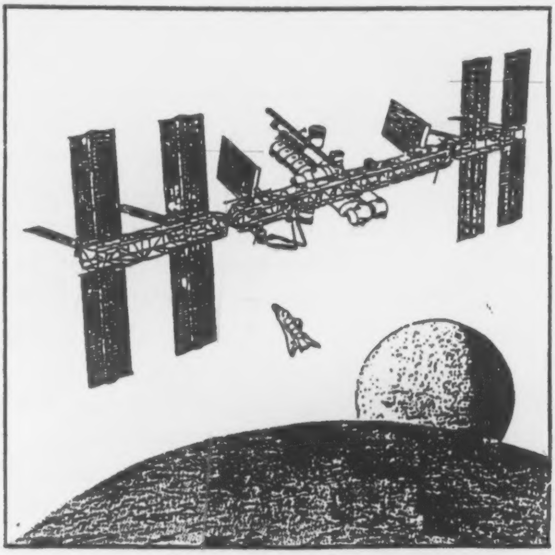
Hold for Release Until
Presented by Witness

July 23, 1990

Subcommittee on Space Science and Applications

Committee on Science, Space and Technology

United States House of Representatives



Statement by
James T. Rose
Assistant Administrator
for Commercial Programs

101st Congress

Statement of

James T. Rose
Assistant Administrator
Office of Commercial Programs
National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
U.S. House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I am proud to be here this morning to present to you and the people of Missouri two exciting and important program areas within NASA. Though these programs are not within the mainstream of NASA's exploration and science missions, through them NASA proactively applies our knowledge, assets, and capabilities to directly contribute to the competitiveness of American industry. By actively applying technology used to solve problems in space to producing new and improved products on earth by the private sector, and by encouraging industry to pursue opportunities that space itself offers for developing new products or services, we are strengthening our nation's competitive position within an expanding global economy.

NASA has an aggressive, long-standing technology transfer program. Economic studies conducted on the subject have determined that for every $1 spent by NASA on space endeavors, the nation has realized at least $8 in return. A 1988 study conducted by the Midwest Research Institute in Kansas City, Missouri, and entitled ***Economic Impact and Technological Progress of NASA Research and Development Expenditures***, has recently concluded that the estimated yield to the U.S. economy is $9 for every $1 invested. The study finds that $148 billion (1982 dollars) spent on NASA R&D during the 1960 to 1986 time period, returned to the economy, through new business generation in a broad range of industrial sectors, approximately $1,338 billion through 1986. The discounted rate of return ranges from 19 to 35 percent per year. Given the magnitude of such economic returns from research and development, we must continue to invest in America's competitive future.

Space-faring nations know that scientific discovery and technological innovation lead to products and services that can benefit people throughout the world. Space has become an industrial laboratory for materials research and processing, and there is tantalizing evidence that unique products of high value may be processed in the weightless, high-vacuum environment of space. This means opportunities for new industries, new jobs, and new products and services to benefit the people of America. The U.S. must focus its ample assets and expertise to position ourselves to compete more favorably with Nations that can, from past experiences, be aggressive and forceful competitors.

True commercial development occurs when new markets, new products and services, and new sources of capital are developed in the private sector, thus contributing to growth of the gross national product. In the face of foreign competition, the pace of development is also important. Markets can be lost because of slow timing or imprecise action. Other countries are targeting segments of commercial development in a focused, cohesive manner. For U.S. industry to compete effectively against foreign firms receiving direct or indirect government support, cooperation between the public and private sectors of this country is necessary. Our railroad system and airline industry obtained their start through cooperation between the public and private sectors.

We believe that we have established aggressive, comprehensive programs at NASA that will help the U.S. compete favorably in a world market. Through these programs we are providing opportunities for the private sector to create new products and services, provide new jobs and markets, and to perpetuate the American quality of life.

Commercial Use of Space

The goal of commercial development of space is to stimulate the growth of the U.S. economy. Initiatives which are geared to serve private markets and which will be developed by private investments are significantly more effective in expanding our nation's economy than initiatives which rely on the public sector as the investor and user. For true commercial development of space to expand beyond the current communications field, private markets and products must be developed in new areas of communications, remote sensing, and microgravity.

The government's strategy is to encourage the private sector to establish the technology and development base that can lead to new products and markets, and second, to encourage their development of infrastructure and transportation industries which can contribute to the creation of these product markets. The government accomplishes this by supporting research programs and space infrastructure. As products and markets mature, the necessary infrastructure and transportation industries will be available to support both NASA and commercial applications.

We must constantly remember that it will be the private sector that will develop ~~commercial~~ space, not government. Therefore, how we implement government programs that may encourage the private sector is important. Issues concerning competition, confidentiality of data, protection of intellectual property, and risk management can jeopardize the success of cooperative ventures.

In commercial development of space, it is important that the U.S. Government not interfere with industry's natural developmental process or change the way industry does business. Rather, the government should seek ways to encourage industry to move along paths that the private sector already knows best.

In implementing government/industry cooperative programs, a strategy must be developed through which the government can continue to meet its public responsibility while working in a collaborative manner.

Centers for the Commercial Development of Space (CCDS) are a network of 16 competitively selected consortia of university, industry and government performing research of potential technologies that the industry partners believe can lead to new commercial applications. The use of grants and the CCDS, we believe, provides the proper approach to developing new products and services for private markets with the direct involvement of 175 companies and 58 universities nationwide. Supporting the development of technologies needed to define markets will stimulate the need for space transportation and infrastructure, which can then be acquired in a conventional commercial way.

Through the grant program the CCDS are allowed to develop (in a totally commercial fashion) equipment, technology, supporting infrastructure, and transportation services. The CCDS's will also provide an organizational focus that will allow continued expansion in these fields. In this way, as markets mature, specific transportation systems and infrastructural services will be developing together. These transportation and infrastructure elements, after being commercially developed and demonstrated, will find government applications because they will have been proven both reliable and cost-effective.

Industry has demonstrated its commitment by investing heavily in the CCDS program. In fact, industry is now investing $2.2, in cash or in-kind services, for every $1.0 the government invests in the program -- and that investment is paying off. The CCDS's have had 18 patents approved and have 41 pending. There have been 778 publications in refereed journals to date, and 91 are in work. The CCDS's have generated 5 spinoff companies or products, brought about the first successful federally licensed commercial launch, and are developing a program that involves commercial expendable launch vehicles (ELVs) with return module capability.

The CCDS' currently have sixty-one new technologies under development in which space may show a significant benefit. Over the next five years, each technology will require a specific number of flight tests to mature it to the point that a decision can be made by the industrial partners regarding the viability of commercial applications. NASA has planned for approximately 277 flight tests aboard the Shuttle, commercially procured sounding rockets and ELV's, and a Shuttle borne commercial carrier to accommodate the program for the five year period. By allowing the CCDS's to procure transportation and carrier infrastructure in a totally commercial way, we are helping American companies to develop a service which could potentially be in demand world-wide some time in the future.

As these 61 technologies mature, a percentage of them are expected to be carried forward into full development programs and commercial applications. Eight such development programs are already underway in the remote sensing area.

Within the next year we expect to see significant progress in our program. During FY 1991, 23 flight tests are scheduled to be carried out; we anticipate 3 technology areas to mature; and we should witness 2 of the 8 development programs moving into commercial applications.

Technology Utilization

For more than three decades, NASA has been developing advanced technology to meet its aeronautical and space goals. Tens of thousands of spinoff products and processes have emerged from the reapplication of technology developed for NASA mainline programs, each contributing some measure of benefit to the national economy, productivity, or lifestyle. These spinoffs span such a broad range of public needs and conveniences that it is difficult to find an area of everyday life they have not pervaded. Collectively, they represent a substantial dividend on the national investment in aerospace research.

The space program provides a focus for high technology development within this country. Without the exploration and science missions, some of the technology that supports the American standard of living would not have come about. We could not have developed these spinoffs randomly, as the cost would have been prohibitive and the conception of ideas sporadic. In today's competitive environment, it is even more important to focus our efforts on the most promising technologies.

Exploring the Benefits

A study entitled, ***An Exploration of Benefits from NASA "Spinoff,"*** published by the Chapman Research Group, Inc. in June 1989, evaluated benefits derived from NASA spinoff technology. Of 441 separate instances of applied technology reviewed, 368 (83 percent) acknowledged contributions toward savings or sales. Not all respondents would share savings or sales figures, therefore only 259 cases were quantifiable. Of the 259 cases, these spinoffs resulted in sales of $21.3 billion, and $315.7 million in savings over an eight year period from 1978 through 1986. From these figures, it is estimated that, during that period, these spinoffs resulted in approximately $356 million in corporate income taxes being paid and over 352,000 jobs being created or saved.

The study also identified a wide spectrum of less tangible, but certainly no less important benefits from the extensive range of NASA spinoffs. In numerous cases the technology proved useful by helping to solve a problem, improve a process, or develop a product. In some instances, it made possible technological breakthroughs important to a particular research community, or resulted in significant commercial benefits further down the line.

Some respondents to the study acknowledged that through spinoff technology, compliance with safety specifications was made easier, public safety and working conditions were improved, employee morale was boosted, and the instances of injury or death were reduced. Instances of improved medical diagnosis and treatment increased patient comfort and facilitated a more normal life. These are all benefits to which monetary terms are not easily attached, but which the people directly involved determined to be special and extraordinarily valuable.

NASA facilitates the transfer of spinoff technology through a variety of methods which include both dissemination of information and technology application projects.

Technology Dissemination

NASA's network of 10 Industrial Applications Centers (IAC) is the key component of the technology dissemination system. The IAC's cultivate strong ties with industry, identify client problems and interests, and assist through the exchange of technological information. The IAC's are backed by a score of Affiliates, state-sponsored business and technical assistance centers, that provide access to the technology transfer network. The network now resides in 41 of the 50 states, including Missouri.

Publications are another important feature of the technology dissemination function. ***Tech Briefs*** provides information on NASA research innovations and is distributed monthly to approximately 200,000 members of U.S. industry. NASA's annual ***Spinoff*** magazine is intended to heighten awareness among potential users of NASA-developed technology. It describes mainline NASA efforts in major programs that generate new technology and the mechanisms NASA uses to stimulate technology development.

Technology Application

Technology applications are accomplished through interaction with public and private sectors of the economy to identify specific needs or problems and develop potential solutions through adaptation of aerospace developed technologies. Currently, there are 73 jointly-sponsored application projects underway at the 9 NASA field installations.

Spinoff/Application Projects

In addition to the many exciting spinoffs such as the pacemaker, graphite tennis racket, cordless tools, and polarizing sunglasses, the following are but a few examples of spinoff or application projects that have occurred in the State of Missouri:

a. Tech House Tornado Detector. The Technology Utilization House (Tech House) was designed and built by NASA to demonstrate how the application of aerospace technology could advance the building industry. Special systems and features, all outgrowth of NASA's aerospace technology, were incorporated into Tech House. A resulting device manufactured by Marketing Inputs, St. Louis, the Tech House Tornado Detector, attaches to the television set which is tuned to any unused channel. Using the television's electronics, the system detects a tornado within 18 miles of the home and sounds an alarm.

b. Auto Microbic System. Manufactured by Vitek Systems, Inc., Hazelwood, the Auto Microbic System, developed from space-biomedical research, is an automatic time saving system for detecting and identifying disease producing microorganisms in the human body. Specimens are exposed to microbe nutrients for the nine most common pathogens. During a 4 to 13 hour incubating cycle, a scanner studies each specimen once an hour. Changes in cell growth on each culture are monitored by computer. When growth reaches a predetermined level, it indicates presence of pathogens. The System automatically enumerates the pathogens and specifies the type.

c. Fire Resistent Materials. Fire hazard is greater in atmospheres containing a high percentage of oxygen under pressure. NASA intensified its fire safety research after a 1967 Apollo fire. A chemically treated fabric called Durette, developed by Monsanto Company, which will not burn or produce noxious fumes was selected as a material for Apollo astronaut garments. Monsanto sold the rights for this material to Fire Safe Products, St. Louis. Durette is now used for a wide range of applications such as: sheets and attendants' uniforms in pressure chambers; furniture and interior walls of diving chambers; and suits for auto racers, refuelers and crew chiefs.

d. Athletic Shoes. Three dimensional "space material" used in the Apollo lunar boots has been encapsulated in a polyurethane foam carrier and forms the base of the Dynacoil Athletic shoe cushioning system. Kangaroos

USA, Chesterfield, developed the system. The shoes lose almost none of their shock absorbing capabilities and have superior stability and motion control. The company plans to extend Dynacoil to other products.

e. Oil Saving Seal. Oil in an automobile must be replaced every few thousand miles, not because it wears out, but because it becomes contaminated. A synthetic rubber ring developed from NASA technology used to withstand the environmental extremes of interplanetary flight, is manufactured by TRW Ramsey Corporation in St. Louis, and functions as a sealing gasket between the metal piston ring and piston. The rubber ring is designed so that gas pressure increases the sealing effect. As the outer metal piston ring wears under long use, the synthetic seal expands to fill wear gaps, thus maintaining a tight seal for engine pistons.

f. Drying of Agricultural Crops. McDonnell Douglas Corporation, St. Louis, developed a new method of drying agricultural crops derived from vacuum chamber technology for testing spacecraft and components called MIVAC. A distant cousin of the home microwave, MIVAC dries by means of electrically generated microwaves introduced to a crop contained within a vacuum chamber. Microwaves remove moisture quickly and the very low pressure in the chamber permits effective drying at much lower than customary temperatures. Energy demand is doubly reduced by the lower heat requirement and by the shorter time electric power is needed.

g. Magnetic Resonance Imaging. Since the early 1970's a series of satellites have been observing our planet. Computer enhanced pictures from these satellites have been used to detect erosion, urban growth, and environmental changes. These satellite image processing techniques are now being used for a new body scanning capability called magnetic resonance. The computerized pictures resulting from the technology appear the same as X-rays. However, X-rays are bone sensitive and the magnetic resonance is sensitive to other tissue such as in the brain. The new scanning technology will improve disease detection and diagnosis.

A unit of the Washington University School of Medicine, the Mallinckrodt Institute of Radiology (MIR), located in St. Louis, is the largest radiology computer facility in the world and has been working for many years in perfecting applications for the magnetic resonance and digital imaging technology.

A list of additional down to earth examples of spinoff technology from the aerospace program is found in table 1.

Small Business Innovation Research Program (SBIR)

A third proactive program area, the SBIR program, can also contribute to U.S. industrial growth. The SBIR Program, established by law, strengthens our competitive position by stimulating technological innovation in the private sector, strengthening the role of small business in federal R&D programs, encouraging greater participation of minority and disadvantaged persons in technological innovation, and increasing private sector commercial development of innovations derived from federal R&D.

Since the inception of the Program in 1983, NASA has awarded 1,243 Phase I contracts (including 249 during 1989) to determine the feasibility of innovative concepts proposed by small business. Of the nearly 1,000 Phase I projects in our Program which have been completed to date, 510 have been selected for further development under Phase II contracts. A phase I award was presented to Incubator Technologies, Inc. of Rolla, Missouri, in 1987 to develop a model for predicting failure in ceramic matrix composites. A company called Laser Data Technology of St. Louis also won a Phase I award in 1988. This award was for developing a Laser communication system design. This project went on to receive a Phase II contract award.

An initial assessment of SBIR Program accomplishments, conducted more than a year ago, indicated that all SBIR objectives were being achieved. The assessment revealed almost unanimous support for the Program. It has brought new ideas and sources of R&D to the Agency, permitted expansion of research areas and provided innovative solutions to problems. Research conducted in the SBIR program is viewed as very high in quality because of the focus on products and the imagination and dedication of the participating small firms. More than half of the projects that had been completed were already incorporated or were planned for incorporation into NASA mission programs.

Our assessment also found that at least one-fourth of the completed projects had resulted in early commercial products or enterprises by the small businesses. The assessment also indicated that a substantial number of minority and disadvantaged firms had won SBIR contracts for high-technology projects.

Conclusion

I would like to highlight the Paul Harvey article attached at the end of this testimony which acknowledges the many great benefits to be realized by the American people from technological advances achieved through the space program.

The breadth and diversity of aerospace spinoffs emphasizes the scope of the benefits accrued from the space program. Some spinoffs offer only moderate increments of economic gain or lifestyle improvement; many others, however, have economic values running to millions of dollars. Collectively, they represent a substantial return on the national investment in aerospace research in terms of contribution to the U.S. economy, job production, industrial productivity, lifestyle innovations and solutions to problems of public concern.

What we as a nation invest in the space program today, will decide the benefits which we will reap in the future. There is no question that a sound, progressive space program that includes exploratory and science missions will not only answer man's questions of science, but will provide a technology stimulus to help America grow economically and socially, with continual improvements in the quality of life for the world.

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Biographical
Data

JAMES T. ROSE
Assistant Administrator for Commercial Programs
National Aeronautics and Space Administration
Washington, DC

James T. Rose became Assistant Administrator for Commercial Programs on October 5, 1987. This office provides a focus for and facilitates efforts within NASA to expand U.S. private sector investment and involvement in civil space-related activities and supports innovative research by small business firms.

Prior to his current assignment, he was Director for Space in NASA's Office of Aeronautics and Space Technology. From 1976 to 1986 he was Director of McDonnell Douglas' Electrophoresis Operations in Space program. He also previously held a series of key positions at the McDonnell Douglas Astronautics Company from 1964 to 1974.

Mr. Rose began his career at NASA's Langley Research Center in 1957 as a research engineer supporting the Vanguard Program experiments. He was assigned to NASA's Space Task Group in 1959 and was asked in 1962 to head the Manned Spacecraft Center's Mission Planning Office for all of the Gemini flights.

He returned to NASA in 1974 as Director of Space Shuttle Engineering in the Office of Spaceflight. Leaving the agency to head McDonnell Douglas' space manufacturing initiatives, he again rejoined NASA in January 1987 as Director of the Space Flight/Space Station Integration Office before being appointed to his present position.

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October 1987

Mr. **Volkmer**. Thank you very much, Jim.

Charlie.

Mr. **Walker**. Mr. Chairman, members of the subcommittee, I appreciate very much this opportunity to testify on this important subject of the future of commercial space industry. Mr. Chairman, I will summarize here my prepared testimony.

I believe it is necessary to put this sector of future United States space activity in a context and to connect it with other space activities that this nation will be conducting over the next 20 years.

I see some significant and relevant trends in our world. For instance, external change will continue to put pressure on the policies and the institutions of this nation. Eastern Europe and the Soviet Union for instance, I do not believe will stabilize for many years. There are significant economic interactions that are going to be happening between western market-driven economies and what were formerly planned economies of the old eastern block countries.

Technological hegemony of the United States that has so clearly eroded over the past two decades, I believe unfortunately will not be restored over the next two decades. I see technological and economic leveling among the most developed western nations continuing to happen.

The control of information and channels of communication will become an increasingly powerful political and economic tool.

Global, regional and national environmental concerns will continue to escalate. The pressures on resources and environments will increase around the world.

The population explosion problem is still with us. One billion more people on this planet a decade from now. And by 2010 perhaps eight billion people will influence all aspects of international life. Economic conflicts may replace political and ideological conflicts as we all compete for the same limited resources.

This nation's space program will be influenced by these trends and others. I think the important question here is how should our space efforts contribute to the resolution of problems while growing in its diversity and its overall benefit to humanity. To continue as a public investment and to be significant in the commercial sector, our space program will have to demonstrate relevance to the many needs of the time.

Our space programs will continue to create new wealth for the United States, even as they stimulate new technologies, make the discoveries of knowledge that may later find innovative application and develop the human talent that will contribute to a competitive, leadership nation.

Our national policy should work to increase the share that both privatization and commercialization hold in our future space activities. Ultimately, as Jim was very clear in saying, only private capital can successfully apply space technology to the improvement of U.S. competitive edge and our balance of trade.

Without reliable, very low cost access to and return from space, no significant continuing investments that can result in broad economic returns will be forthcoming.

The government must play a role, a positive role, in encouraging and establishing this transportation revolution.

Specifically, I would suggest that in order to encourage this absolutely vital element in the development of a strong space industry, the following must happen or continue to happen:

(1) That there be a clear separation between operations-oriented and research-oriented launch vehicle programs.

(2) That there be hammered out a political commitment to space access and return without specific payloads in our hand.

(3) Existing international agreements be adhered to and enforced, while seeking fair rules of the road for all launch competitors.

(4) And lastly, investment by the U.S. government in launch infrastructure and cost-reducing technologies in operations, manufacturing and propulsion.

All programs can benefit from improvements in space transportation, primarily through reduced program costs. Consequently, increased private sector commercial R&D in space will soon lead to commercial products and services directly applicable to government programs.

For instance, Mission to Planet Earth could benefit from a commercial operational foundation. I specifically would recommend to this Committee's consideration a proposal made by the 1989 Report of the Center for Strategic and International Studies review of Civil Space Policy that suggests commercializing the satellite arm of NOAA.

The Space Station Freedom Program, of which McDonnell Douglas is a major participant, and the proposed human Space Exploration Initiative, in which McDonnell Douglas intends to be a major participant, both will benefit from a reduction in transportation costs, and through application of commercially developed and proven hardware systems and services, significantly reduced life-cycle costs. In the long-term, simply having access to the infrastructure developed under these public programs will be a boon to industry. From R&D in laboratories, discoveries come after human tinkering and expert evaluation, often taking place in real time. That is no different in the investigation of physical processes on earth or in orbit.

Tomorrow, what can we expect when we have truly surveyed the moon and developed the systems necessary to support humans and remote systems there and on Mars? I do not know. But no one knows that we will not make revolutionary discoveries or develop invaluable tools for terrestrial application. Historically in reaching for and exploring every new human frontier, the rewards have immeasurably exceeded the costs. I have faith that this fact will continue to hold true.

In the end, I believe that the basic interest that humanity has in space must be recognized to be the finding of resources necessary for the continued improvement of the human condition. One planet is a limited place with limited resources. We must think for the long-term.

Solar powered satellites beaming power to the earth's surface must be investigated to answer both the increasing energy demands required to maintain comfortable economies and the effects of continued terrestrial fuel and renewable fuel use. When we have really opened economic access to space, expect to see resources and processes open up that will answer many of our problems right here on earth.

For instance, perhaps the dumping of radioactive and chemically contaminated wastes into the sun, the ultimate disposal. Beyond space as an economic resource is outer space as a place for human experience. No environment or location has ever been discovered by humans that was not soon explored and with human presence then staying on the expand the known realm. These explorations and expansions have been driven by stresses and pressures at home, wherever that home may have been. Now the vast spaces and worlds beyond our home—earth—offer us the answer to many of our present and I believe our future needs. It is time that we get on with that future.

Thank you.

[The prepared statement of Mr. Walker follows:]

Statement of Charles D. Walker, Special Assistant to the President for Space Programs Development, McDonnell Douglas Space Systems Company

Before the U.S. House of Representatives Subcommittee on Space Science and Applications of the Committee on Science, Space, and Technology

July 23, 1990 in St. Louis, Missouri

Mr. Chairman and members of the subcommittee, I appreciate this opportunity to testify on the important subject of future commercial space industry. I believe it necessary to put this sector of future U.S. space activity in a context and connect it with the other space activities that this nation may be pursuing simultaneously over the next twenty years.

External change will continue to stress the policies and institutions of this nation over the next twenty years. The political, cultural and economic dynamics of the democratization of Eastern Europe and the Soviet Union will not stabilize for many years. A new trend in economic interaction between the western market-driven economies and the formerly planned economies of the old Eastern block countries will expand.

The technological hegemony of the U.S., so clearly eroded over the past two decades, will not be restored over the next two decades, in my opinion. Quite to the contrary, I believe. A technological, and economic, leveling will take place among the most developed western countries. The European Economic Community will be a powerful innovator.

The development and control of information and channels of communication will become a powerful political and economic tool over the next few years.

Global, regional and national environmental concerns will continue to escalate for some time. I believe the negative influence of human activities will grow globally even as regional accords are put into effect. The pressures on resources and environments will increase around the Earth as technology and economic growth in the underdeveloped nations escalates.

Human population growth, the population explosion problem so much discussed in the 1970s, is still with us. One billion more people than today will be alive on this planet a decade from now. The resource and living space needs of a world population of perhaps eight billion people by the year 2010 will influence all aspects of international life. Economic conflicts may well replace political and ideological conflicts between nations over that period of future time.

This nation's space program will be influenced by these trends and others, but how? The important question is how should our space efforts contribute to the resolution of problems while growing in its diversity and overall benefit to humanity. I believe that to continue as a public investment and to be significant in the commercial sector our space programs will have to demonstrate relevance to the many needs of the time. A continuing vigorous and balanced set of space programs must draw upon both public and private sector resources.

This nation's past space programs of exploration and utilization have made significant economic and aesthetic contributions. They will continue to do so. Our space programs will create new wealth for the U.S. even as they stimulate the new technologies, make the discoveries of knowledge that may later find innovative application, and develop the human talent that will contribute to a competitive, leadership nation.

The future of space industry can be expected to consist of the traditional privatization of government space-related assets to the private sector, as well as true commercial activities. Commercialization I define as the provision of products and services that involve private capital at risk to exploit the attributes of space and their associated market applications. Our national policies should work to increase the share that both privatization and commercialization hold in our future space activities. Ultimately only private capital can successfully apply space technology to the improvement of the U.S. competitive edge and balance of trade.

The need to innovate, to be competitive with other nations in the world wide marketplace of the future, will involve the increasing application of technology and scientific discoveries from our space programs. But without reliable, very low cost access to and return from space no significant, continuing investments that can result in broad economic returns will be forthcoming.

The government must play a positive role in encouraging and establishing this transportation revolution and what the National

Commission on Space called the "Highway to Space". New technologies and applications must be demonstrated. Programs and allowances must be made that will show the financial and industrial communities that, in fact, a new frontier is available to them at a price they can afford. Specifically, I would suggest that in order to encourage this absolutely vital element in the development of a strong space industry the following must happen: 1.) there be a clear separation between operations-oriented and research-oriented launch vehicle programs; 2.) there be hammered out a political commitment to space access (and return) without specific payloads in hand; 3.) existing international agreements be adhered to and enforced, while seeking "fair rules of the road" for all launch competitors; and, 4.) investment by the U.S. government in launch infrastructure and cost-reducing technologies in operations, manufacturing, and propulsion.

All NASA and other civil space programs, existing or under consideration, can benefit from improvements in space transportation -- primarily in reduced program costs. But increased private sector commercial R & D in space will soon lead to commercial products and services directly applicable to government programs. That is, space-developed products for space applications, off-the-shelf.

Mission to Planet Earth could benefit from a commercial operational foundation. Beyond just commercial launch services during the many years of this program, the availability of commercial remote sensing data streams could be of significance. Scientific instruments could ride along on commercial platforms. I would specifically recommend to this committee's consideration the proposal made by the 1989 Report of the Center for Strategic and International Studies review of Civil Space Policy in commercializing the satellite arm of NOAA and revise the commercial aspects of EOSAT and NASA earth observing research.

The Space Station Freedom program and the proposed human space exploration initiative would both clearly benefit from a reduction in transportation cost. But more, I believe, that again the application of commercially developed and proven hardware, systems and services, developed by appropriate government support and the incentive of real, reduced launch costs, would significantly reduce life-cycle costs. In the long-term, simply having access to the infrastructure developed under these public programs will be a boon to industry. The laboratory of orbital environments with human participation in the research and development tasks is analogous to any laboratory here on the Earth's surface. Discoveries come after human tinkering and expert evaluation, often in real-time. It is no different in the investigation of physical processes in orbit.

And what can we expect when we have truly surveyed the Moon and developed the systems necessary to support humans and remote systems there and on Mars? I don't know. No one does. But no one knows that we won't make revolutionary discoveries or develop invaluable tools for terrestrial application! Historically, in reaching for and exploring every new human frontier the rewards have immeasurably exceeded the costs. I have faith this fact will continue to hold true.

In the end, I believe, that the basic interest humanity has in space must be recognized to be finding the resources necessary for the continuing improvement of the human condition. One planet is a limited place with limited resources. Humanity is rapidly proving to be a strain on these limited resources and environments. We must think for the long-term. If we do we will find that the inexhaustible energy and material resources of our solar system are technically available to us. Solar power satellites beaming power to the Earth's surface must be investigated to answer both the increasing energy demands required to maintain a comfortable economy and the effects of continued terrestrial fossil and renewable fuel use. The vastness of space and the unique environments there will be utilized by industry when economic access is available. And beyond being technically available there needs to be the will to go. When that comes expect to see resources and processes open up that will answer many of our problems. For instance, perhaps the the dumping of radioactive and chemically contaminated wastes into the sun -- the ultimate disposal.

But beyond space as an economic resource is outer space as a place for human experience. No environment or location has ever been discovered by humans that wasn't soon explored, with a human presence then staying on to expand the known realm and establish a permanent existence. These explorations and expansions have been driven by stresses and pressures at "home". It is time that we recognize that the vast spaces and worlds beyond our "home" offer us the answers to many of our present and future needs. It is time that we get on with that future.

CHARLES D. WALKER

BIOGRAPHICAL INFORMATION

Charles D. Walker is President and Chairman of the Executive Committee of the National Space Society. He also serves as Chairman of the Board of Directors of Spacecause.

Walker was the first non-career, industry-sponsored astronaut, serving as payload specialist on Space Shuttle missions; STS-12 (41-D) in September, 1984; STS-16 (51-D) in April, 1985; and STS-23 (61-B) in November, 1985. On those flights, Walker operated equipment designed by McDonnell Douglas Astronautics Company for its biotechnology commercialization program named EOS and accumulated 20 days and 7.1 million miles of space flight experience.

The EOS device, developed under a joint agreement between McDonnell Douglas and NASA, produced large, pure quantities of pharmaceuticals when operated in the weightlessness of space. As chief test engineer of the EOS program, Walker was extensively involved with the laboratory development and space flight test of the EOS device. Walker had also been responsible for training NASA astronauts in the operation of the EOS device.

Walker, who is presently Special Assistant to the President of McDonnell Douglas Space Systems Company for Space Programs Development, joined McDonnell Douglas in 1977. His initial assignment was that of test engineer on the aft propulsion subsystem for the Space Shuttle orbiters. Currently in Washington, D.C., Walker is supporting McDonnell Douglas on technical issues. Walker has been a member of an independent national space policy review project and served on a National Research Council space board.

A native of Bedford, Indiana, Walker received his undergraduate degree in aeronautical and astronautical engineering from Purdue University in 1971. He was awarded an honorary doctor of science from St. Louis College of Pharmacy in 1985. Prior to joining McDonnell Douglas, Walker was a project engineer with the Naval Sea Systems Command in computer-controlled manufacturing systems, design engineer for Bendix Aerospace and, previous to that, an engineering technician and firefighter with the U.S. Forest Service.

Mr. Volkmer. Thank you very much, Charlie. When we decided we were going to have to leave early, we decided we would not have any questions, but you have saved us about five minutes, so I will recognize the gentleman from Missouri if he has any questions of this panel.

Mr. Buechner. I would like to ask Charlie—

Mr. Volkmer. We will go with one question from each member.

Mr. Buechner. Okay. Charlie, I would just like to ask what—McDonnell Douglas has established some work in the pharmaceutical research area of space. Can you talk about that a little bit and what plans they have to continue to do that?

Mr. Walker. Well Mr. Buechner, McDonnell Douglas pursued for a period of ten years an effort, doing research and development in the purification of pharmaceutical materials using the unique weightless environment of space. The effort in effect ended in 1986 with the Challenger accident. It was deemed that it was just an inappropriate business expense, we could not continue to invest in that activity because of the then clear restraints on access to space, most likely the increased cost of access to space, we just were not going to be able to continue to invest in it for probably as much as another ten years from that point before we had a positive return on investment.

The equipment is in fact now in the hands of the National Aeronautics and Space Administration and they, I believe, are making plans to utilize that equipment for continued use by the nation, by researchers, government and industry, in that vein.

Let me just add to that that McDonnell Douglas, however, has not completely left behind its interest in that area. McDonnell Douglas is certainly supporting the development of infrastructure which will allow not only continued research in that area perhaps by others, but research in all areas of materials and sciences on a commercial basis in space—the Spacehab project. McDonnell Douglas is also involved, through one of the Centers for the Commercial Development of Space that Mr. Rose mentioned, in the investigation of space applied coatings to medical implants. And the intent here is using the weightless environment of space to improve the coatings on metallic implants in correcting bone deficiencies. The thought is—in fact the theoretical research indicates that these new beneficial coatings will in fact prevent the kinds of rejection and the loss of strength of those implants that have been a problem for so long in the implant medical arena.

Mr. Volkmer. If the gentleman will yield. Charlie, I would like you to correct me if I am wrong and take my statement not as a question, but the electrophoresis process was not a complete waste. You gathered quite a bit of information. We were able to find, were we not, that the processing space, we ended up with more purity of the product and a better way to do it. And the information, the knowledge that we gained is something that could lead to other things later on. Correct?

Mr. Walker. You are absolutely right, Mr. Chairman. As a matter of fact, there are several elements of the program that, while as it turns out we could not continue with at McDonnell Douglas, have in fact spurred economic activity and benefits in the medical community generally. For instance, the big push that we put on in developing genetically engineered tissue and cell lines for the production of pharmaceutical materials in raw form, have been utilized around this country to tremendous benefit to the medical industry. In addition, as I said, the technologies we developed are now in the hands of NASA and will be continued, I believe, to very beneficial use.

And I might say that some of the research that we helped promote by researchers at Penn State University, in looking into the use and production of human growth hormone, we are now in fact seeing the expanded interest in human growth hormone as perhaps a means to diminish the infirmities that we can all expect to see in old age. And so, I think that particular area in fact was stimulated somewhat by our work.

Mr. VOLKMER. Jim, we have got still about a minute and a half of Charlie's time. Jim Hayes may have to wait for his question until the next panel, but we discussed this a little bit last night. Would you just elaborate a little bit on what is occurring with NASA in the electrophoresis process.

Mr. ROSE. We learned an awful lot from that program. The technology is valid. It is a separation device, it is significantly improved in space. Genetic engineering has come along and found other means to produce large quantities of material. That does not mean they do not need purification, it just means that some techniques on the ground are applicable. Space still offers the potential that this technology will—can be done more cost effectively, which means we can bring the same product to the patient much cheaper. When we know how much space is going to cost and how we are going to physically operate there, I believe you will see electrophoresis return.

Since I purchased the equipment from NASA at the cost of transfer—I mean from McDonnell, one of our centers, Penn State, one of our commercial centers, is very anxious to get into a focus looking at space as a place to do separation work as a business for some of their companies working with them. They are coming to see me in about a week with a proposal on how they will use electrophoresis and how it will fit into the strategy that they are coming forthwith. If their program makes sense, then I propose that we will lend them the equipment that we now have, which is McDonnell derived and developed equipment, to continue that research program. But yes, I believe you are going to see electrophoresis continue to be a major technology that will find a space application.

Mr. VOLKMER. Thank you. Jimmy—the gentleman from Louisiana have any questions—one question. Do not take too long.

Mr. HAYES. No.

Mr. VOLKMER. No questions. I want to thank both Jim Rose and Charlie Walker for your testimony here today. I appreciate seeing you again in this environment. That will conclude our first panel.

Our second panel will be Mr. Al Kehlet, Vice President and Deputy General Manager for McDonnell Douglas Space Systems Company, Delta Launch Vehicle Division. We also have—we were scheduled to have Dr. Lovelace, but he is busy down in Florida right now so we have Charles Lloyd from General Dynamics Commercial Launch Services and Ms. Stephanie Lee-Miller, Director, Office of Commercial Space Transportation, United States Department of Transportation.

I would appreciate—since we have got three on this panel and three on the next panel and we have a total of half an hour, that gives you ten minutes each. Since we are now two minutes into that, that breaks you down to nine minutes each. Your statement will be made part of the record at the point at which you testify. You may either summarize or review it if you can do it in nine minutes, you can review it in total.

We will begin and receive your testimony in the order in which you were called to the table, so we will begin with Mr. Kehlet.

STATEMENTS OF ALAN KEHLET, VICE PRESIDENT/DEPUTY GENERAL MANAGER, MCDONNELL DOUGLAS SPACE SYSTEMS COMPANY, DELTA LAUNCH VEHICLE DIVISION; CHARLES LLOYD, GENERAL DYNAMICS, COMMERCIAL LAUNCH SERVICES AND STEPHANIE LEE-MILLER, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, U. S. DEPARTMENT OF TRANSPORTATION

Mr. Kehlet. Thank you very much, Mr. Chairman. I would like to summarize my paper.

This year, the Delta launch vehicle will celebrate 30 years of launches for the United States government and commercial launches. Also we will celebrate our 200th launch later on in the month of November.

I would like to have two principal messages in two categories and the first is our actual experiences on the Delta and the second message is a forecast of the future.

McDonnell has been actively marketing the Delta II to commercial customers and we have received ten firm orders worth approximately $500 million for commercial launches through 1991.

We have learned a lot of lessons through our experience with this fledgling industry. The most important is that to gain commercial customers and to keep them satisfied, a track record of many successful launches is essential. And due to the previous support by NASA and DOT to the Delta team, the Delta rocket has achieved a launch record of 61 successful missions of the last 62 attempts in the last 13 years. This equates to a reliability record of 98.4 percent, which we believe is the world's best record. Cost is also an important factor to our customer, but if the launch is not successful, insurance will pay for the launch vehicle but it will not pay for the years of lost business and revenue while waiting for another launch opportunity.

We are now launching at the rate of one a month, 12 a year. Six of those are the U.S. Air Force NAVSTAR global positioning satellites and the other six are government, civil as well as commercial launches.

Our future, from the ten launches we have so far under contract, is not as bright as it might seem. Demand by the commercial communications satellite market in the free world is declining and we expect by the mid-1990s it will be only about 50 percent of the 20 a year that we now see, down to a steady state of about 10 to 12.

Demand for this launch service will decline and level off in the coming decade, the number of potential competitors is increasing. In the past three years, Delta, Titan and Atlas have faced intense competition from the European Ariane. However, the non-economy countries have been actively courting potential customers. In a few years the Japanese could offer a commercial launch vehicle by their H-II. So by the late 1990s, no less than seven competitors, if we all stay viable, will be chasing a very limited international commercial launch market. Part of that reason is the high cost of launch. In order to increase the market share in the late 1990s, as Mr. Rose and Mr. Walker have talked about, we need to reduce the cost of our launch vehicle.

Now also part of our problem is the fact that in the United States, our launch prices are established by the need to not only recover costs but to generate a reasonable return on investment, and this certainly is not the case for the non-market economies.

We feel that the commercial launch vehicle business is a very viable business and the reduction of that could mean the loss of many jobs in many areas. Where today there are over 20,000 Americans employed by the U.S. launch manufacturers and servicers and related support industries.

Mr. BUECHNER. Mr. Kehlet, could you move your microphone a little further in to you and speak into it there? Thank you.

Mr. KEHLET. Furthermore, a strong launch business is good for the U.S. because it significantly helps reduce the nation's trade deficit. The average value of a single U.S. launcher on a U.S. satellite exported to an international customer is worth approximately $120 million, which is roughly equivalent to the import of 12,000 cars

To ensure the viability of our commercial launch enterprises, three actions are needed.

First, as mentioned before, we must adhere to existing agreements, because agreements not adhered to are not agreements.

Secondly, we need fair rules of the road as far as what is offered by the competition, not only price-wise, but also let us say technology transfer.

And third, probably the most important thing is we need to generate new investments with the support of the U.S. government in the launch vehicle industry and its infrastructure. We have many new ideas in the use of propulsion, materials and processes that could reduce the cost of the launch vehicles. Industry alone cannot be expected to do all of the investment in what we consider a high-risk, ill defined commercial market.

I would like to illustrate this by pointing out what happened to McDonnell Douglas in the case of the payload assist module, or the PAM. In 1984, when the national space policy was to launch all commercial satellites on a space shuttle, McDonnell Douglas invested $200 million in developing two payload assist modules. We expected 90 missions to occur to achieve a reasonable return on investment and because of the Challenger accident, we only launched 20. So we are a long ways away from getting a return on investment in that particular aspect, even though there was changes in the national space policy.

I would like to now show a video of a series of launches of the Delta launch vehicle and then conclude with one concluding remark.

So could I have the video please?

What we are going to show here is some launches for SDIO on Delta Number 181 and another vehicle called Delta Star, which we are doing research for SDIO.

The video contains not only the two SDIO missions but also a joint NASA/German project called ROSAT which had a new ten foot fairing on the vehicle. Also, we will be showing the commercial Indonesian Polopa launch which was one of the satellites recovered by the Shuttle. The other satellite was the Asiasat launched by the Chinese.

And also, on the video is a NASA project COBE, which was launched from Vandenburg by the Delta rocket. And then there is an Air Force NAVSTAR—the first of the Delta II launches. And a remark about that is that we never had test launches. We changed the Delta vehicle over a period of time and each launch is always a new vehicle, but it is a live launch.

Okay, this is the SDIO experiment.

The ROSAT experiment with a new ten foot fairing on it.

Some of the photography you will see from the pictures taken by the NASA and Air Force cameras, you will see the solid rockets coming off, six of them are ignited on the ground along with the main propulsion and then later on the three additional rockets are jettisoned.

Even when it is on video, I still get the feeling of the countdown and the liftoff.

At liftoff we have six of the solids and the main engine burning. At one minute into the launch, the additional three solids are lit and then the six solids are then separated. Some of the—as I mentioned before, the photography is just absolutely outstanding, to be able to see the separation of those six rockets.

Later on we will see at two minutes into the flight the three additional rockets separate. At this time, the vehicle is 20 miles away, 100,000 feet up. Now you can see the rockets coming on.

This is a launch from Vandenburg and it is the first time we had a launch at Vandenburg in five years. So restoring the launch complex and the tower was quite an undertaking. But the crew was the same crew that we use on the east coast, we just transfer them to Vandenburg, so that the same procedures are used on the west coast that we use on the east coast.

This mission is a fairly low altitude mission, it was up about 300 miles. Now the NAVSTAR is the first vehicle we built which we stretched the tanks of the Delta and put a new fairing on it, so essentially it is a new configuration. All total, in the next—within the past couple of years and this year, we will launch ten different configurations of the Delta vehicle.

We used to say this is how to get simultaneous launches.

[Laughter.]

Mr. **Kehlet**. And so our first flight of the new configuration was very successful. We had moderate changes to the configuration to take care of some acoustics after that first flight, so we learn from each and every flight.

Now in this case, the satellite was placed 12,000 miles up. Our last launch is the commercial launch for India, the Department of Space for India, called the INSAT. We launched it at night and there was a full moon and we had the rocket go right across the face of the moon.

My concluding remark is that even though we have been very successful with Delta over 30 years, we have increased the payload from 200 pounds low earth orbit to 11,000 pounds in the past 30 years, the vehicle is still based on a design which goes back to the Apollo and the Shuttle days where performance was the design criteria and not cost. That result is we have what we call a matched system. If something happens on the system, such as with the propulsion, the main propulsion, we have any particular problems with it, it usually ends up that we have to pull the whole engine and take it back to the factory and redo the hot firing because it is a matched system as opposed to a modular system. So in the future, as we get down to the low-cost and we do have to drive the cost down on the vehicle, we need the propulsion which occupies about 50 percent of the total cost of the vehicle, to be much less expensive, much more robust and modular in design. We need separate engines for the strap-ons, a high performance engine for the core and certainly a high performance engine for the second and third stages.

So with that, thank you.

[The prepared statement of Mr. Kehlet follows:]

STATEMENT BY
ALAN B. KEHLET
VICE PRESIDENT DEPUTY GENERAL MANAGER
DELTA LAUNCH VEHICLE DIVISION
MCDONNELL DOUGLAS SPACE SYSTEMS COMPANY

BEFORE THE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

JULY 23, 1990
ST. LOUIS, MO

Thank you Mr. Chairman and the members of the Subcommittee on Space Science and Applications for the invitation to testify on the developing commercial space launch industry. My name is Alan Kehlet. I am the Vice President-Deputy General Manager of the Delta Launch Vehicle Division of the McDonnell Douglas Space Systems Company.

My principal messages are in two categories. The first is a summary of our actual experiences in the use of the Delta launch vehicle to provide commercial space launch services. The second message relates to our forecast for the future of the U.S. commercial launch business.

After the Challenger accident, U.S. Government policy mandated that commercial satellites were to be launched by commercial launch vehicles. As a result, many projects were off-loaded from the Shuttle program, and a viable U.S. space transportation business grew strong enough to support and promote healthy and fair competition between our Delta, Martin Marietta's Titan, and General Dynamics' Atlas.

McDonnell Douglas has been actively marketing the Delta II to commercial customers, and has received ten firm orders to date worth approximately $500 million for commercial launches through 1991.

On July 15, 1987, MDSSC was selected to launch two satellites built by the Hughes Aircraft Company for British Satellite Broadcasting LTD., a British consortium. The satellites will establish a direct satellite-to-home broadcasting system in Europe. We successfully launched the first U.S. commercial communications satellite on August 27, 1989, when BSB R-1 was successfully placed into orbit for an ecstatic customer. The second BSB launch is scheduled for next month on a Delta II rocket.

Additional commercial contracts have been signed for Indonesia, India, Inmarsat, NATO, GE-American, and Contel ASC.

Currently, there are two Delta launch pads in operation--17A and 17B. McDonnell Douglas has negotiated with the Air Force and NASA on the use of government-owned launch pads and range services at Space Launch Complex 17 at the Cape Canaveral Air Force Station.

We have learned many lessons through our experience in this fledgling commercial launch business. The most important lesson is that, to gain commercial customers and keep them satisfied, a track record of many successful launches is essential. Due to previous support by NASA and DOD to the Delta team, the Delta rocket has achieved a launch record of 61 successful missions out of the last 62 attempts--a ratio of 98.4%--the world's best record. Cost is also an important factor to customers, but if the launch is not successful, insurance will not pay for years of lost business and revenue while waiting for another launch opportunity. So, high quality is also an important criteria for our customers.

That relates to another interesting lesson. In the medium-size satellites serviced by the Delta system, commercial customers get the same high degree of quality standards expected by NASA and DOD. Our policy is to build all Delta's to the same high degree of quality oversight and standards that was established over the last 30 years of experience launching a total of 197 Deltas. Every Delta II booster is now interchangeable with all missions for any customer -- whether commercial communications, or NASA scientific, or Air Force NAVSTAR.

Therefore, the commonality of launch vehicles and launch operations between different missions is an important part of high reliability, on-time launch schedules, and lowest costs to all customers. Maintaining Delta's current launch rate of 12 per year from Cape Canaveral is essential and continuing improvements to range facilities and scheduling are needed to assure safe and timely launches.

Now turning to the future--the commercial launch picture as I see it is not as bright as our experience might suggest.

Demand by commercial communications satellite customers in the free world is declining. By the mid 1990's it is estimated that a 50 percent reduction of the current commercial launch rate will occur-down from 20 launches per year to a steady state of about 10 to 12 launches per year. This forecast is shared by several experts in the field.

Two principal reasons will lead to this lower demand. The post Challenger "bow wave" has crested and will dissipate entirely by 1994. In addition, some projects being proposed have not been able to secure financing because of the high cost of dedicated communications systems.

While the demand for launch services will decline and level off in the coming decade, the number of potential competitors is increasing. In the past three years, Delta, Titan, and Atlas have faced intense competition from the European Ariane. Today, foreign competitors including the non-market based suppliers have been actively courting potential customers as well. In a few more years, the Japanese could offer launch competition with their H-II vehicle. So, by the late 1990s, no less than seven competitors--if they all stay viable--will be chasing a very limited international commercial launch market.

This problem of a shrinking market size and an expanding number of players has been compounded by foreign pricing and trade practices that are significantly different from U.S. offers. U.S. launch prices are established by the need to cover costs and get a reasonable return on private investment. This is not the case for the non-market players.

Consider that there are now in place several agreements that apply to the commercial space launch business. One of those agreements requires future launch bids be "on a par with" prices that are prevailing in the international market place. Supporting documentation attached to that agreement defines the phrase "on a par with" as meaning "similar to" Western offers. The dictionary defines "par" as "equal to." But in the past year, offers by the non-market bidders have been for a price that is one-half or less than those of Western prices.

In addition, there have been offers to transfer critical weapons related technologies to underdeveloped nations. The bottom line is that if existing inequalities in prices and questionable trade practices continue unabated, it will spell a sharp decline, and perhaps the demise, of the U.S. commercial launch business.

The loss of commercial launch vehicle business in the U.S. will also mean the loss or reduction of jobs in many areas. Today, there are over 20 thousand Americans employed by U.S. launch vehicle manufacturers and services and related support industries.

Furthermore, strong commercial space business is good for the U.S. because it helps to significantly reduce the nation's trade deficit. The average value of a single U.S. launcher with a U.S. satellite "exported" to an international customer is approximately $120 million, which is roughly equivalent to a value of 12,000 "imported" cars.

Also, we need to consider the implications of the transfer of critical technologies to developing nations of the world. The developed countries must practice the ethical responsibility to minimize the transfer of critical technologies to unfriendly countries. We must remain vigilant and be aware that much of the technology we take for granted in commercial launch vehicles can easily be adapted to and used for weapons purposes. To ensure the viability of or commercial launch enterprises, three solutions are appropriate.

The first--and most important today--is to insist on adherence to existing agreements. There are existing agreements that cover pricing, technology transfer, and trade. These must be honored--because if agreements are not adhered to, the result will be the continually eroding business for the U.S. space industry and,ultimately, no commercial space launch capability in this country.

Second, we should also seek the creation of "fair rules of the road" for all competitors. Fair rules must include fair pricing, fair trade, and the establishing of fair ethical standards on business conduct. Such rules or regulations should make ample provisions for effective controls and binding enforcement mechanisms for all participants.

Third, we need to generate new investments, with the support of the U.S. government, in long-term new technologies and in the development of new vehicles and modern launch facilities to significantly reduce the cost of delivery to space. We in the U.S. launch industry must cut costs and maintain high quality to compete. New ideas in propulsion, materials, and launch operations are only a few of the many ways to a more permanent solution. Financing is not easy, but the government can help by investing in space technologies and infrastructures and by creating policies that put more incentives into financing and reduce the risks of financial losses.

Your support on these three actions is vital to ensuring and maintaining a healthy, viable, and successful U.S. commercial space business. Our future generations of Americans and the rest of the world will look back with appreciation to the bold steps we take in acting today on our beliefs and convictions.

Thank you very much.

MCDONNELL DOUGLAS

McDonnell Douglas Space Systems Company

BIOGRAPHICAL SKETCH

Alan. B. Kehlet

Alan B. Kehlet was born in Chicago, Illinois on February 8, 1929. He graduated from Joliet Township High School, attended Joliet Junior College (1947), and was graduated from the University of Illinois (BS-Aeronautical Engineering, 1951). He received his post graduate degrees from the University of Virginia (MS-Aeronautical Engineering 1961) and the California State College (MBA 1976). Following graduation from the University of Illinois, he was employed by the National Advisory Committee for Aeronautics (NACA) as a Research Scientist, working on the aerodynamics of missiles, airplanes and space vehicles. At the creation of the National Aeronautical and Space Administration (NASA), he was selected as one of the original 35 members of the Space Task Group (later the NASA Johnson Space Center) to design and develop the United States manned space program from Mercury, Gemini and Apollo, to the Space Shuttle. In 1962, he was employed by Rockwell International as Apollo Chief Project Engineer, to develop the Apollo spacecraft modules.

In 1968, Mr. Kehlet was named Apollo Assistant Program Manager to direct the manufacturing, checkout, launch and recovery of Apollo 11, the first Apollo lunar landing mission. At completion of the Apollo 11 mission, he was named Chief Engineer of the Rockwell Space Shuttle program. After being instrumental in winning the hardware competition for the Space Shuttle in 1972, he was named Sabreliner Division Chief Engineer, to develop and market a new model series of business jet airplanes. The very successful Sabreliner Model 65 (the first transcontinental business jet with advanced aerodynamics and fan jet engines) was certified under his leadership.

In 1978, Mr. Kehlet was promoted to Executive Vice President of Rockwell's turbo prop airplane division and shortly thereafter, was promoted to President of the Sabreliner Division. In 1982, he left Rockwell to become President of the Fairchild Aircraft Company.

Two years later he joined McDonnell Douglas as Vice President of Engineering and Operations of the Astronautics Company. In 1985, he accepted the position of Vice President General Manager of the Tomahawk Cruise Missile program for McDonnell Douglas. In this capacity he directed all elements of the Tomahawk Weapon Systems.

Mr. **Volkmer**. Thank you very much, Mr. Kehlet.

Mr. Lloyd.

Mr. **Lloyd**. Thank you, Mr. Chairman. As you mentioned, Dr. Lovelace is unable to attend, and to paraphrase a well-known political comment, I know Dr. Lovelace, I serve with him and I am no Dr. Lovelace, but I will certainly try to do my best to represent him. As you said, he is down at the Cape right now. We are making an attempt to launch our first commercially procured launch. We will be trying today around 3:30, weather permitting.

In 1987, Dr. Lovelace testified before this Subcommittee and outlined a program that General Dynamics had started on, to the tune of a commitment for 18 launch vehicles, about $100 million in nonrecurring costs. We had no customers for that program at that point in time.

What I would like to do very briefly is give you a status report on that program and then talk about some other items.

Since 1987, we established a subsidiary called the Commercial Launch Services subsidiary, which I have the pleasure of heading up in San Diego. We have, in addition to those first 18 vehicles, made a further commitment for 62 launch vehicles to be launched through 1998. We have, at this point in time commitments for about 41 of those particular launches. We have invested or will have invested through the end of next year over $400 million of General Dynamics' stockholders' money. Now I realize $400 million in the grand scheme of things in the U.S. government perhaps does not sound like a great deal of money, but I can assure you to the stockholders of our company, that represents a significant commitment.

That $400 million is for the engineering, for revitalization of the launch pads, tooling and other capital facilities around the country. What we bought for that $400 million—and if we could turn on the overhead projector—what that bought is basically the capabilities—we try to launch them the other way.

[Laughter.]

Mr. **Lloyd**. Up—there you go, that is the way we try to put them. Most of the time they do go that way.

Regardless, we have four separate models of Atlas launch vehicles that will generate capabilities from about 5000 pounds geosynchronous transfer orbit to almost 8000 pounds. We will develop those. The last model, the Atlas II AS model, will be—have its first launch in the first quarter of 1993 and it is one that NASA just recently made a commitment to procure for one of their science payloads.

We believe that in doing so, committing to these launch vehicles and particular committing to the growth, we have reduced the cost to orbit significantly. In fact, NASA, to the government, if you go back and look at the prior launch vehicles that were procured in the 1986-1987 time frame compared to the vehicles that NASA is buying now and the cost of those launch vehicles, we have cut the cost to the government just about in half in terms of the ability to put a payload in orbit.

We would also certainly over the last three years like to congratulate our colleagues in this business. McDonnell Douglas we think has done just an outstanding job. We also congratulate the

Orbital Sciences Corporation with their Pegasus program and certainly Martin Marietta with the Titan. We think that those three vehicles, along with the Atlas, provide this country with a firm base for transportation, probably certainly over the next ten years.

However, we also believe that there need to be certain things that are done to improve and to guarantee our success in the future. We think we need a stable transportation space policy. We think we need a policy that ensures free but fair competition and fair trade. We think we need to have some modernization and upgrade of our existing vehicles. We think that the government can, perhaps as a partner with the industry, do that sort of thing. We think that eventually there has to be some development of a new system, whether it is called the advanced launch system or some other particular element. We think it needs to enhance some of the elements that my colleague just talked about in terms of reliability, modularization and lower cost.

However, we do believe that the U.S. industry can be competitive. And in fact, since we have started in this business roughly in the 1987-1988 time frame, we have been successful in about 50 percent of the competitions we have had with Ariane in terms of free and fair competition for international launch opportunities.

To speak just a moment about foreign competition, as you well know, all of our foreign competition, the non-recurring aspects of their program are 100 percent government funded. In the case of the General Dynamics' Atlas, previous to the Challenger disaster, that was also the case. However, since then the $400 million has been funded by General Dynamics and in addition to profit, not only do we have to recover the profit in our price, we have to recover that $400 million in our price, something which none of our international competitors have to do.

To give you an example of what the foreign competitors are doing, Ariane is investing four to five billion dollars in a new launch vehicle, the Ariane V. They hope to improve the performance of their current system and reduce the cost to orbit by some 45 percent.

Now we do not encourage a return back to the old way of doing business, but we do believe that NASA and the Air Force can support the ELV industry through component technology development similar to the way they have done the aeronautical technology development program over the years. And as I mentioned before, we also believe that some new launch vehicle needs to be procured and built probably some time after the year 2000.

Let me touch briefly on competition between free market and non-market economies. This is something that I am sure each of you are aware of and have read with some interest, particularly in the space press. We believe that uncontrolled entry in the non-market economy would cause severe market disruption. As a result, we are at this time opposed to U.S. participation of the Soviets at Cape York. However, we are realists and understand that the political realities of the world have changed and as a result that some entry may be approved. However, we believe that before any sort of arrangements are made for such a thing, we believe that the policy of the U.S. government should be made clear. We believe that that policy should be established before the U.S. and ESA agree to the entry of the USSR into this area.

We also believe that bilateral negotiations with the Europeans, the European Space Agency, should be taken to set, if you will, the rules of the road, which seems to be the phrase that is most popular when talking about this particular element.

We further believe that any agreement must have specific terms and conditions that are both workable and enforceable. Charlie Walker spoke to that a bit earlier. We do not believe that the agreement with the Chinese represents a good model for that agreement. We think that certain elements were not clear, certain terms, such as pricing on par, were not clearly defined and in particular we are concerned that the mechanisms for enforcement of those particular agreements were not specified and were not made clear.

In terms of legislative language, recommendations for legislation if you will, we believe that NASA and the U.S. government agencies should acquire their commercial launch requirements from the U.S. commercial flag carriers. As I pointed out to some of the Congressional staff members that were down at our attempted launch the other day, if they looked up on the fairing, they would see the American flag on that fairing and to remember as they go through these consultations, that those vehicles that might fly from the Chinese Republic or Cape York or the Soviet Union, would not have an American flag on the side of their launch vehicle. And I asked them to consider that when they go through their considerations.

We think these procurements should be done in a commercially reasonable manner with an emphasis on specifying mission performance requirements. However, we do believe that the procuring agencies should be allowed to exercise their rights and obligations to the taxpayers for some level of insight into our programs.

In closing, I commend the Committee for their interest in the continued support of the U.S. commercial ELV industry. I think as a result of that, the Committee recognizes that the transportation element is a key point in our national space policy and although I understand the environment that you people are going through in terms of the budget situation, I believe that the proper investments in ELVs is important to our country's future in space.

Mr. Chairman, I appreciate the opportunity to pass on our remarks today.

[The prepared statement of Mr. Lloyd, plus the biographical sketch of Dr. Alan Lovelace follow:]

Mr. Chairman, I appreciate the opportunity to appear before your subcommittee today and offer my views on the future of the commercial expendable launch vehicle industry. The industry in general and General Dynamics in particular have matured significantly in recent years,experiencing a number of successes as well as failures. Overall, I feel the industry has the potential to grow and flourish, creating several thousand jobs for our domestic work force, contributing to the nation's economy, improving the balance of trade and strengthening the nation's presence in space. This fledgling industry is faced with a number of critical issues, however, that threaten its very survival.

Before I address these issues, I would like to take this opportunity to discuss the recent accomplishments of General Dynamics relative to Commercial ELVs. Since last appearing before your subcommittee nearly three years ago, we have created a separate Commercial Launch Services subsidiary to focus on the commercial launch industry. At that hearing, I discussed the bold business initiative to manufacture 18 Atlas/Centaur vehicles financed solely by General Dynamics' investment of funds. In 1988, the Corporation took an even bolder move, increasing the number of launch vehicles to 62. This allowed us to significantly reduce the price of Atlas/Centaur and pass the savings on to the Air Force in 1988 when General Dynamics captured the MLV II competition to launch 10 DSCS satellites. To date, General Dynamics has invested more than $400 million in the Atlas/Centaur program for launch vehicle improvements and manufacturing and launch facility upgrades. The result is a family of Atlas launch vehicles (Attachment A) capable of launching up to 7,700 pounds into geosynchronous transfer orbit. Our manufacturing facilities include one of the largest known clean rooms in the free world, a test facility capable of simulating both acoustic and thermal environments to thoroughly test upper stages and spacecraft, and two launch pads at Cape Canaveral having a combined launch rate capacity of up to ten per year.

To date, more than 40 of the 62 launch vehicles have been sold. Customers include the Air Force and NASA, as well as domestic and foreign commercial business users.

Additionally, I have been pleased to see the successes of other Commercial ELV manufacturers, including the McDonnell Douglas Delta ELV and the Orbital Sciences Corporation Pegasus, a unique and innovative air-launched small expendable launch vehicle. The Atlas, Delta and Pegasus represent the future of the U.S. Commercial ELV industry. They have demonstrated, through their successes, the ability to participate in a highly competitive international market.

While General Dynamics and others have thus far realized a number of early successes, we at General Dynamics look to the future with deep concern due to a number of issues which I would like to discuss now.

If the Commercial ELV industry is going to succeed in the future, it will require a modernization effort of significant proportion. The Atlas, for example, while it has undergone a number of improvements over the years as it achieved a record 495 launches, is still based on the Atlas ICBM developed in the late '50s. As I stated earlier, we have been relatively successful in the international market thus far. It is important to realize, however, that foreign governments are sponsoring new launch capability developments that will significantly weaken U.S. competitiveness. These include the Ariane 5 vehicle under development by the European Space Agency, the Japanese H-2 Rocket, the Chinese Long March 4, and the Soviet Zenit.

It is also important to note that the development of these expendable launch vehicles is being funded primarily by their respective governments; and further, when these systems are fully operational and competing in the open market, the price will not include amortization of these same development costs. These launch vehicles will be very capable systems that address many of the shortcomings of current ELVs we read about and discuss over and over — improved reliability and operability at reduced costs.

To illustrate the magnitude of the investment required and the results of that investment, the Ariane 5 is anticipated to be operational in the mid-to-late 1990s. The European Space Agency by that time will have invested $5-$6 Billion in the design of the launch vehicle as well as a new launch complex. The result will be a 10% reduction in per-launch cost, which translates to a 45% reduction in cost per pound to orbit when considering the improved performance capability.

In today's environment, U.S. commercial operators cannot afford the major investments required to develop new launch vehicles or make major enhancements to existing vehicles.

General Dynamics has invested a significant amount of money into the Atlas program, resulting in a lower cost and a more reliable system. We are continuing to look for ways to improve Atlas, including the infusion of new technologies developed under the Advanced Launch System. More can be done, however, with the support of the U.S. Government and NASA in particular.

There are substantial NASA efforts underway to advance U.S. commercial aeronautical technology through the NASA Langley and Lewis Research Centers. These initiatives include such technologies as unducted fan, VSTOL and supercritical wings. NASA should take a similar approach and become the modernizing agent for commercial ELV technology. NASA should reinvigorate its leadership in ELV technology development for transfer to the commercial sector. This ELV component technology effort should be directed toward near term (next five years) improvements of existing vehicle technology. Efforts should focus on cost reduction and improved operability. If this is not done, U.S. ELV technology will certainly fall behind our foreign competitors.

To compete beyond 2000, it is recommended that a new commercial ELV be developed that embraces many of the philosophies of the joint USAF/NASA Advanced Launch Development Program (ALDP), formerly Advanced Launch System (ALS). This program is centered around the design of a total launch system that is robust, highly reliable, responsive and low in cost. Incorporated in this program are both new technology developments and innovative applications of existing technologies from inside and outside the aerospace industry. In short, this is the United States' first clean-sheet look at what is the most cost-effective way to put cargo into space. Unfortunately, due to a series of funding reductions, the program no longer focuses on total launch system development. This is unfortunate because the opportunity embodied in the original ALS philosophy is unique in its scope — development of technologies and techniques which benefit a promising industry, a launch system to affordably meet the science and defense needs of the next century as well as the next-generation commercial launch requirements, thus ensuring U.S. competitiveness in the highly competitive world market.

I would like now to turn to another critical issue facing the U.S. Commercial Launch industry — that being competition between free market and non-market economies. The entrance of Chinese and Soviet non-market controlled economies into the space industry, coupled with the wherewithal to offer capable launch vehicles at prices substantially below Western free market prices, will cause severe market disruption and will only undermine all the programs and investment incurred to develop the space industry.

U.S. Government policy has been instrumental in helping to develop other markets such as commercial aviation, the maritime industry and the railroad industry. A similar policy should be implemented to support the Commercial ELV industry to secure U.S. technological and economic benefits and obtain solid market presence.

Specifically, we recommend that access to the U.S. space market by non-market economy nations be strictly controlled until free market conditions are stabilized. During this period, the U.S. should continue to build its space infrastructure by initiating an aggressive program to upgrade and expand current U.S. Government space technology with a concentration on enhancing accessibility to space. This would allow the U.S. industry to become stronger against foreign non-market competitors when they enter the world market.

The U.S. should duplicate the international practice of France/Europe, China and the Soviet Union by reserving U.S. Government spacecraft launch demand for U.S. competitors. It is important to note that these countries have lobbied for access to the U.S. Government space markets while at the same time defending their right to keep home government markets closed.

The political reality of reduced tension with the Soviet Union coupled with expanded economic cooperation indicates that the United States will eventually accommodate Soviet entry into the commercial launch market. Prior to entering into this agreement, the National Commercial Space Launch Policy being developed by the National Space Council should be completed. This policy should, among other things, provide terms and conditions with the Soviet Union that are workable and enforceable, something that does not currently exist in the agreement with the Chinese. Bilateral negotiations must be completed with the Europeans, establishing agreed-upon principles of free and fair trade and identifying a common front toward non-market providers.

At this time I would like to address, in general terms, recommended language for any legislation to be passed in support of the Commercial ELV industry.

First, as was discussed earlier, it should contain language requiring NASA and other U.S. Government agencies to acquire unmanned launch services from U.S. Commercial Flag Carriers. This would provide a stable policy for the U.S. Commercial ELV industry to plan its investment strategy and is consistent with European Space Agency and other foreign government space organization policy.

There should be provisions calling for procurement in a commercial manner. Specifically, the customer should be able to procure the basic launch vehicle off a single production line with the manufacturer controlling the basic vehicle configuration. This has been and will continue to be of benefit to Government customers on a wide variety of missions.

The legislation should encourage specifying mission performance requirements, similar to what NASA has done on the Small Expendable Launch Vehicle procurement, but not preclude the use of peculiar specifications where judged appropriate.

There should not be any language to preclude the procuring agency from exercising its rights and obligations to provide a reasonable level of insight into the contractor's performance.

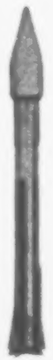
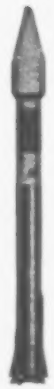
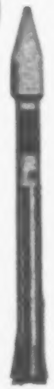
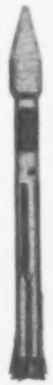
Finally, NASA should be authorized to look ahead at the next generation of ELVs that will be required to serve civil government, military, and commercial needs past the year 2000. It is recommended that this effort be specific and focused toward the reduced launch costs and improved reliability that will ensure future competitiveness.

In closing, I would like to commend your Committee for your interest in and continued support of the U.S. Commercial ELV industry. I know that in this time on unprecedented budget pressures, it is difficult to provide funding for new programs. I feel strongly, however, that with the proper Government and industry cooperation the ELV industry will flourish, providing a strong economic base of jobs for several thousand Americans and ensuring that the U.S. maintains a strong presence in space.

Mr. Chairman, this concludes my remarks. I will now address questions you or Members of your Subcommittee may wish to ask.

GENERAL DYNAMICS
Commercial Launch Services

THE COMMERCIAL ATLAS FAMILY CAPABILITIES

	ATLAS I	ATLAS II	ATLAS IIA	ATLAS IIAS
				
PAYLOAD SYSTEM WEIGHT TO GTO	2,245 KG (4,950 LB)	2,675 KG (5,900 LB)	2,810 KG (6,200 LB)	3,490 KG (7,700 LB)
INITIAL LAUNCH CAPABILITY	2ND QTR 1990	1ST QTR 1991	4TH QTR 1991	1ST QTR 1993

14-FT PLF SHOWN (11-FT PLF OPTIONAL)

Performance shown here is payload system weight, which includes spacecraft, payload adapter, and mission-peculiar hardware. Typical payload adapter and mission-peculiar hardware weight is 60 kg (130 lb).

GSV90-1342

Exhibit A

GENERAL DYNAMICS CORPORATION
Pierre Laclede Center
St. Louis, Missouri 63105

314-889-8200

ALAN M. LOVELACE

Biographical Sketch

Dr. Alan M. Lovelace was appointed corporate vice president and general manager of Space Systems Division, General Dynamics Corporation, in March 1985. He also serves as president of Commercial Launch Services subsidiary of General Dynamics Space Systems Division. Dr. Lovelace joined General Dynamics in July 1981 after serving as acting administrator of the National Aeronautics and Space Administration since January of 1981. While at General Dynamics Corporate Office, Dr. Lovelace held the positions of vice president - science and engineering and vice president - productivity and quality assurance.

Dr. Lovelace joined NASA in 1974 as associate administrator for the Office of Aeronautics and Space Technology. He was named deputy administrator in June 1976 by President Ford. Since entering Federal service with the U.S. Air Force in 1954, he has held many research management positions. He served at the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, from 1954 through 1972, having been named director in 1967. From 1972 to 1973, he served as director of science and technology with the Air Force Systems Command, Andrews Air Force Base, Washington, D.C. From 1973 to 1974, Dr. Lovelace was principal deputy assistant secretary of the Air Force for research and development. Dr. Lovelace retired as deputy administrator of NASA in December 1980 but stayed with the administration through the first flight of the Space Shuttle Columbia and the appointment of a new administrator.

Born in St. Petersburg, Florida, in 1929, Dr. Lovelace received bachelor's, master's and doctoral degrees in chemistry from the University of Florida. Awards he has received include the President's Citizens Medal, the Department of Defense Exceptional Service Medal, the Air Force Decoration for Exceptional Service, the National Civil Service League Career Service Award, the Office of Aerospace Research Award for Outstanding Contributions to Research, the 1984 von Karman Medal and the 1989 AIAA Goddard Astronautics Award.

He is a fellow and past president of American Institute of Aeronautics and Astronautics and is a member of the National Academy of Engineering, the International Academy of Astronautics, the Air Force Association, Sigma Xi and Phi Beta Kappa.

Married to the former Kathryn Logan of Bridgeport, Connecticut, the Lovelaces have two children.

# # #

January 1990

Mr. VOLKMER. Thank you very much.

Stephanie.

Ms. LEE-MILLER. Mr. Chairman, Congressmen, I will be cognizant of the pressure that we are all operating under.

Mr. VOLKMER. Fine.

Ms. LEE-MILLER. Thank you very much, Mr. Chairman, for inviting me to address the Committee this morning.

Mr. VOLKMER. Pull the mike just a little closer, Stephanie.

Ms. LEE-MILLER. Congressman Hayes and Buechner as well. I appreciate the opportunity to present to you a brief overview, a report card if you will, of really the overall look at where we are now within commercial space transportation and the impact that we have seen on the economy.

This has been a great year for the U.S. commercial space launch industry. There have been eight successful missions so far and we have a ninth waiting on the pad even as we speak. The industry has gotten off to a good start and continues to show impressive development. We will release a new manifest in September that will show an addition of six new contracts for commercial launches and a total of 35 flights expected to take place in the next several years. Our customers will include Great Britain, Italy, Japan, Sweden, international consortia, NATO and the U.S. government. Companies have invested more than $600 million in this market.

Having a strong, competitive U.S. commercial space program certainly benefits the U.S. economy because our manifests represent a contribution of about $650 million to the U.S. balance of payments and for 1990, the Commerce Department projects revenues of about $1.6 billion for the sales of both launches and satellites.

In addition to the direct profits, there are numerous other benefits of a viable commercial space industry. U.S. leadership in world space and high-tech markets, new space related employment and research, more diversity in our program, consumer goods and so on.

In addition to the contracts reflected in the manifest, we are also seeing new developments occurring in the marketplace. For example, a few weeks ago, Motorola announced plans to establish a new mobile telephone system that will involve 77 light sats. If this is successful and if they launch on U.S. vehicles, this satellite network would be an important addition to the U.S. private launch market. The area of market forecasting is of particular interest to me because we have been using traditional market forecasting techniques in the U.S. which does show a potential marketplace of maybe 20 communications satellites a year and it is not a real bright picture, if you feel that the number is going to go down rather than up.

I think we need to improve and update our market forecasting outlook, because with the investment going on globally, clearly other people see some market out there, and Motorola's recent announcement added 77 light sats to a marketplace. They were not there the week before.

So I am confident that we will see new market applications growing out of programs like Jim Rose's and other research development that will keep this industry viable. So I think the picture is brighter rather than dimmer.

The U.S. will play a leadership role in the world commercial launch market and there are several issues which the previous panelists have touched on that we are concerned about as well at the Department of Transportation. And I can assure you, Secretary Skinner is personally involved and working with the National Space Council on each of the issues that have been referred to earlier.

A major concern we have is that federal regulatory policy and practices be consistent in this industry. The Commercial Space Launch Act which Congress passed had behind it the whole idea of designating a centralized, regulatory source at the Department of Transportation that would give the industry a consistent and predictable regulatory environment to operate within. We think that that is very important to maintain.

At the Department of Transportation, we are responsible for the licensing of the commercial launch service providers and we are continuing to update our procedures to ensure that the cost not be burdensome to industry and that we be efficient in how we constantly modify the licensing program to keep up with changes in the industry.

We are concerned at DOT about the entry of the non-market economies such as the Soviet Union and the People's Republic of China, and we understand the importance that this has for U.S. industry.

In maintaining our technological competitiveness, U.S. firms must be able to deliver cost-effective, reliable and state-of-the-art vehicles. I am very happy to hear Al and Charlie talk about their companies' interest in bringing costs down and upgrading their vehicles because that will maintain our competitive edge.

Transportation infrastructure is vital to the continued development of a robust, competitive commercial space transportation sector and we are seeing initiatives coming out of our states; Hawaii and Florida are leading that, but other initiatives as well. Later this month in Miami, there will be a states' conference where a number of states will get together and talk about how they can play a role in raising private sector dollars, putting in state investment, trying to advocate with the federal government that we expand our launch infrastructure to guarantee that our companies have access to reliable launch slots.

These are a few of the issues facing the U.S. space transportation industry and certainly at DOT in our capacity both as the primary regulator and as our responsibility for facilitation and promotion of this industry, we will continue as a strong advocate in the years to come.

Thank you.

[The prepared statement of Ms. Lee-Miller follows:]

REMARKS OF STEPHANIE LEE-MILLER
DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION
BEFORE THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

ST. LOUIS, MISSOURI
JULY 23, 1990

* * *

LET ME PREFACE MY COMMENTS BY THANKING YOU, MR. CHAIRMAN, AND YOUR COLLEAGUES FOR INVITING ME TO ADDRESS THE SUBCOMMITTEE ON BEHALF OF THE DEPARTMENT OF TRANSPORTATION (DOT). I WOULD ALSO LIKE TO CONVEY BOTH SECRETARY SKINNER'S AND MY OWN APPRECIATION OF YOUR EFFORTS TO SUPPORT THE GROWING U.S. COMMERCIAL SPACE TRANSPORTATION INDUSTRY.

I WOULD LIKE TO BEGIN WITH A BRIEF OVERVIEW OF THE OUTLOOK FOR THE U.S. COMMERCIAL SPACE TRANSPORTATION INDUSTRY AND ITS IMPACT ON OUR ECONOMY AND THEN MENTION SOME OF THE ISSUES WHICH WILL HAVE AN IMPACT ON THE CONTINUED SUCCESS OF THE INDUSTRY, BOTH AT HOME AND IN THE INCREASINGLY CROWDED WORLD COMMERCIAL LAUNCH MARKET.

THIS IS AN IMPORTANT YEAR FOR THE U.S. COMMERCIAL SPACE LAUNCH INDUSTRY. WITH A TOTAL OF **NINE** SUCCESSFUL MISSIONS **[PRESUMING CRRES IS LAUNCHED SUCCESSFULLY BEFORE THIS SPEECH]**, THE INDUSTRY HAS GOTTEN OFF TO AN IMPRESSIVE START AND IT CONTINUES TO SHOW SUBSTANTIAL DEVELOPMENT. DOT IS PREPARING TO ISSUE A REVISED COMMERCIAL LAUNCH MANIFEST WHICH SHOWS AN

ADDITION OF SIX NEW CONTRACTS FOR COMMERCIAL LAUNCHES, AND A TOTAL OF 35 FLIGHTS EXPECTED TO TAKE PLACE IN THE NEXT SEVERAL YEARS. THESE MISSIONS WILL SERVE A VARIETY OF CUSTOMERS, INCLUDING GREAT BRITAIN, ITALY, JAPAN, SWEDEN, INTERNATIONAL CONSORTIA, NATO AND THE U.S. GOVERNMENT. U.S. COMPANIES HAVE COLLECTIVELY INVESTED MORE THAN $600 MILLION IN THE MARKET.

A STRONG, COMPETITIVE U.S. COMMERCIAL SPACE PROGRAM ALSO BENEFITS THE U.S. ECONOMY IN SEVERAL WAYS. FOR EXAMPLE, OF THE LAUNCHES LISTED ON THE COMMERCIAL SPACE MANIFEST, 12 ARE FOR FOREIGN CUSTOMERS, REPRESENTING A POTENTIAL BOOST OF APPROXIMATELY $650 MILLION TO THE U.S. BALANCE OF PAYMENTS. ALSO, FOR 1990, THE U.S. COMMERCE DEPARTMENT PROJECTS REVENUES OF MORE THAN $1.6 BILLION FOR THE SALES OF BOTH LAUNCHES AND SATELLITES.

IN ADDITION TO DIRECT PROFITS, THERE ARE MANY OTHER ECONOMIC BENEFITS OF THE COMMERCIAL SPACE INDUSTRY, INCLUDING LEADERSHIP IN THE WORLDWIDE SPACE AND HIGH-TECHNOLOGY MARKETS, THE GENERATION OF NEW SPACE-RELATED EMPLOYMENT AND RESEARCH AND DEVELOPMENT, A MORE DIVERSE SPACE PROGRAM, SALES OF CONSUMER GOODS AND SERVICES, TOURISM, AND INCREASED INTEREST IN SCIENCE AND TECHNOLOGY EDUCATION. AN INTERESTING CASE IN POINT, THE STATE OF FLORIDA, WHICH IS PLANNING TO DEVELOP A COMMERCIAL LAUNCH FACILITY, HAS ESTIMATED THAT EACH COMMERCIAL ORBITAL LAUNCH COULD GENERATE UP TO $13 MILLION IN INDIRECT REVENUES FOR THE STATE.

IN ADDITION TO CONTRACTS REFLECTED IN THE COMMERCIAL LAUNCH MANIFEST, RECENT BUSINESS DEVELOPMENTS PROMISE TO PROVIDE A BOOST TO THE LAUNCH INDUSTRY. FOR EXAMPLE, A FEW WEEKS AGO, MOTOROLA ANNOUNCED PLANS TO ESTABLISH A MOBILE TELEPHONE COMMUNICATIONS NETWORK INVOLVING 77 LIGHT SATELLITES. IF SUCCESSFUL AND IF LAUNCHED ON U.S. VEHICLES, THIS SATELLITE NETWORK WOULD REPRESENT A SIGNIFICANT ADDITION TO THE U.S. PRIVATE LAUNCH MARKET. THE ESTABLISHMENT OF SUCH SYSTEMS ALSO ASSURES CONTINUING LAUNCH BUSINESS AS THESE SATELLITES MUST BE REPLACED AND UPDATED.

WHILE I AM VERY CONFIDENT THAT THE U.S. WILL COME TO PLAY A LEADERSHIP ROLE IN THE WORLD COMMERCIAL LAUNCH MARKET, THERE ARE SEVERAL ISSUES OR CONCERNS IMPORTANT TO THE PRIVATE LAUNCH FIRMS AND THEIR CUSTOMERS. THE DIRECTION THESE ISSUES TAKE IN THE LONG-TERM WILL SHAPE THE FUTURE GROWTH AND COMPETITIVENESS OF THE U.S. LAUNCH INDUSTRY AND THE FUTURE ROLE OF THE UNITED STATES IN THE WORLD COMMERCIAL SPACE TRANSPORTATION MARKET.

ONE CONCERN IS THAT FEDERAL REGULATORY POLICY AND PRACTICES BE CONSISTENTLY SUPPORTIVE OF THE U.S. PRIVATE LAUNCH SECTOR. IN 1984, THE PRESIDENT LAID THE GROUNDWORK FOR BUILDING THIS POLICY ENVIRONMENT BY DESIGNATING ONE FEDERAL AGENCY TO TAKE THE LEAD IN REGULATING THE NEW PRIVATE LAUNCH INDUSTRY. PRIOR TO THAT TIME, A LAUNCH COMPANY WOULD HAVE TO CONSULT MANY DIFFERENT AGENCIES AND WORK ITS WAY THROUGH LAYERS OF RED TAPE BEFORE WINNING THE

GOVERNMENT'S PERMISSION TO CONDUCT A PRIVATE LAUNCH.

THE DEPARTMENT OF TRANSPORTATION IS CONTINUING TO IMPROVE THE LICENSING PROCESS IN WAYS THAT BETTER REFLECT THE WAY COMMERCIAL LAUNCH FIRMS ACTUALLY DO BUSINESS. WE ARE MOVING QUICKLY TO IMPLEMENT A MORE PROGRAMMATIC APPROACH TO LICENSING INVOLVING LICENSES WHICH WILL ENABLE COMPANIES TO CONDUCT SEVERAL LAUNCHES DURING A GIVEN PERIOD OF TIME AND UNDER SIMILAR CIRCUMSTANCES. THE DEPARTMENT IS ALSO WORKING TO DEVELOP AN EFFICIENT MEANS OF REGULATING NEW VEHICLES SUCH AS THE PEGASUS AND NEW FACILITIES SUCH AS COMMERCIAL SPACEPORTS.

U.S. TRADE POLICIES ALSO INFLUENCE THE COMPETITIVE POSITIONS OF U.S. FIRMS IN THE WORLD COMMERCIAL LAUNCH MARKET. FOR EXAMPLE, THE ENTRY OF NON-MARKET ECONOMY NATIONS SUCH AS THE SOVIET UNION AND THE PEOPLE'S REPUBLIC OF CHINA INTO THE COMMERCIAL LAUNCH BUSINESS ARE OF PARTICULAR CONCERN TO U.S. FIRMS.

ANOTHER IMPORTANT ISSUE IS THE NEED TO MAINTAIN TECHNOLOGICAL COMPETITIVENESS. IN ORDER TO CAPTURE AND MAINTAIN A SIGNIFICANT MARKET SHARE, U.S. FIRMS MUST HAVE THE CAPABILITY TO DELIVER COST-EFFECTIVE, RELIABLE, STATE-OF-THE-ART VEHICLES AND LAUNCH SUPPORT SERVICES.

THE QUALITY AND AVAILABILITY OF TRANSPORTATION

INFRASTRUCTURE ARE ALSO VITAL TO THE CONTINUED DEVELOPMENT OF A ROBUST, COMPETITIVE COMMERCIAL SPACE TRANSPORTATION SECTOR.

EXISTING U.S. LAUNCH SITES WERE CONSTRUCTED TO ACCOMMODATE NASA AND MILITARY MISSIONS, NOT COMMERCIAL USERS. AT THESE RANGES, ALTHOUGH EFFORTS ARE MADE TO BALANCE COMPETING PRIORITIES, SOME COMMERCIAL LAUNCHES HAVE RECEIVED LOWER PRIORITY AND HAVE BEEN DELAYED TO MAKE ROOM FOR GOVERNMENT LAUNCHES. THESE DELAYS RESULT IN INCREASED COMMERCIAL LAUNCH COSTS AND LOSS OF CUSTOMERS' CONFIDENCE IN THE RELIABILITY AND COST-EFFICIENCY OF U.S. COMPANIES.

SEVERAL STATES HAVE ALREADY TAKEN STEPS TO EXPLORE THE POSSIBILITY OF CONSTRUCTING COMMERCIAL LAUNCH FACILITIES, INCLUDING FLORIDA, WHERE THE LEGISLATURE HAS ESTABLISHED THE FLORIDA SPACEPORT AUTHORITY AND HAS APPROVED $500 MILLION IN BONDING AUTHORITY. HAWAII ALSO HAS SELECTED TWO POSSIBLE SITES FOR COMMERCIAL LAUNCH FACILITIES AND HAS APPROPRIATED FUNDS FOR AN ENVIRONMENTAL STUDY OF THE SITES.

THESE ARE A FEW OF THE ISSUES FACING THE U.S. COMMERCIAL SPACE TRANSPORTATION INDUSTRY. YOU CAN BE ASSURED THAT THE DEPARTMENT OF TRANSPORTATION WILL CONTINUE ITS ROLE AS AN STRONG ADVOCATE OF THE INDUSTRY IN THE YEARS TO COME. THANK YOU AGAIN FOR YOUR KIND INVITATION AND I WOULD BE HAPPY TO ANSWER ANY QUESTIONS FROM THE SUBCOMMITTEE MEMBERS.

STEPHANIE LEE-MILLER
DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION
DEPARTMENT OF TRANSPORTATION

Stephanie Lee-Miller became Director, Office of Commercial Space Transportation, on April 1, 1989.

In 1983 she was appointed Assistant Secretary for Public Affairs at the Department of Health and Human Services (HHS). At HHS she was responsible for managing all departmental communications, including media relations and speechwriting. She also served as the Secretary's principal advisor on public affairs issues and the Freedom of Information Act.

In 1981 she came to Washington, D.C., from California, and served for two years in the Public Affairs Office at the Department of Commerce.

Ms. Lee-Miller was born in Los Angeles, California, March 7, 1950. She received her bachelor of arts degree in psychology from California State College at Dominguez Hill in 1971 and the master's degree in urban studies from Occidental College in 1975.

For five years Ms. Lee-Miller was with the Coro Foundation of Los Angeles, the first nine months as a fellow in public affairs and then as director of community programs for the foundation. In 1978 Ms. Lee-Miller became director of the NAACP Legal Defense and Educational Fund for the Southern California area.

From July 1979 until February 1981, when she took leave to enter government service, Ms. Lee-Miller was co-owner and managing partner of Contact California in Beverly Hills, a public relations/public affairs consulting firm that provides media relations, marketing and other account services to private companies and non-profit organizations.

Ms. Lee-Miller served as a member of the U.S. delegation to the International Women's Conference in Nairobi, Kenya, in 1985 and in 1987 served as a member of the U.S. delegation to the United Nations Commission on the Status of Women.

Ms. Lee-Miller is on the Board of Directors of the National Council, and a member of the National Links, Inc., and Delta Sigma Theta public service sorority.

She has received numerous awards, including the 1977 Outstanding Young Woman Award, Los Angeles International Soroptimists, and in 1988, the Scroll of Merit Award from the National Medical Association.

Ms. Lee-Miller is a Californian currently residing in the District of Columbia.

April 1989

Mr. **Volkmer**. Thank you very much, Stephanie. The only question I have is, Al and Charlie, you addressed this basically and what concerns some of us I think is if you had to compete against completely subsidized similar type of vehicle that you are now manufacturing from China or Russia, you are just not going to be able to do it, are you?

Mr. **Kehlet**. That is right, Mr. Chairman. The real problem we have with the non-market economies, is regardless of what we do as far as cost reduction of our launch vehicles, they can set the price any place they want to. So driving our costs down to be absolutely competitive with the non-market economies just is not going to work except in the long-run when those economies become more market-oriented.

What driving the prices down in our estimation will do is open up the markets like Jim Rose and Charlie Walker talked about, and Stephanie just talked about on the Motorola. So the real problem now is the $40-$50 million it takes to launch an Atlas or a Delta. If we could get that down to the $20 million mark with multiple payloads on it, then it becomes affordable for the researchers to do their experiments.

Mr. **Volkmer**. Fine. Charlie, do you want to submit anything?

Mr. **Lloyd**. Well I would just say that as we look forward into the end of the decade, as Al mentioned, as the Chinese and the Russians move toward a more market economy, their costs will have to go up. In terms of our particular system, I just talked with Dr. Lovelace the other area and our effort is to reduce our costs. Perhaps as we get to the end of the decade, those points will start to converge and we can have, you know, free and fair competition at lower cost elements, but we would ask for consideration as their economies move toward a more market-driven situation, that is where we need a policy that perhaps gets us out to the late 1990s where our costs are coming down and they are accounThen gentleman from Louisiana, any questions?

Mr. **Hayes**. No, because of the shortness of time, but on another occasion when we have a chance, I would be most interested in getting any materials that you might have that you might supplement to this hearing even, on what kind of availability there is within the Soviet fleet for commercial launch use. The reason I ask that being that the Soviet pressures internally will not drive their economy to subsidize commercial launch services as opposed to eating, which is really what had led toward the kind of pressures they have been under. So to me, one of the keys would be trying to estimate what kind of residual impact their military fleet might have if converted. And secondly, what they have got on hand in order to in the interim compete with us and try to cause you the kind of economic problems of non-market economies.

As I say, we have run out of time, but I would be most interested in pursuing that on another occasion.

Mr. **Kehlet**. We have that information and will share it with you.

Mr. **Hayes**. I would be very interested.

Mr. **Volkmer**. With that, Stephanie, do you have anything you would like to finish up with?

Ms. **Lee-Miller**. Well just to say that we certainly understand the Soviet capability is vast and they have a lot of military hardware they can transfer and bring into the marketplace.

Mr. **Volkmer**. With that, we will conclude this panel. We appreciate you being here and testifying. Your testimony has been very helpful and if we have any additional questions, because of the brevity of time, we will submit them to you in writing and we appreciate you replying to them in writing also.

That will bring us to our final panel of Dr. Dennis Wint, President, St. Louis Science Center; Dean Marty Israel, Washington University and Dr. Robert Walker, Director, McDonnell Center for Space Sciences, Washington University.

Your statements will be made a part of the record at the point at which you testify in the record, and I would appreciate your testimony being given in the order in which you were called to testify. You may either summarize or review your testimony in full.

At this time, I am going to turn the chair over to my friend from Louisiana because I have to—because of something that came up, I have to make a phone call back to my office in Washington. We will start with Dr. Wint, and if you will take over, Jimmy.

STATEMENTS OF DR. DENNIS WINT, PRESIDENT, ST. LOUIS SCIENCE CENTER; DEAN MARTIN ISRAEL, WASHINGTON UNIVERSITY AND DR. ROBERT WALKER, DIRECTOR, MCDONNELL CENTER FOR SPACE SCIENCES, WASHINGTON UNIVERSITY

Dr. **Wint**. Mr. Chairman and members of the Committee, I appreciate the opportunity of speaking with you this morning.

As we attempt to gauge the importance and direction of science education for the next 20 years, it is useful to look at what space science has meant to us in the past two decades. The benefits that we have derived have been numerous and have changed the very fabric of our daily lives, including worldwide communication, understanding natural phenomena and spin-off technologies.

Perhaps the most dramatic example of how far we have come in the past two decades is the way in which we understand our environment. Twenty years ago at the first Earth Day celebration, we could hardly guess at the extent and the seriousness of environmental deterioration. But because of our space exploration, the 1990 Earth Day celebration revealed new scientific information about global environmental quality. Because space exploration has enabled us to see ourselves as a beautiful but fragile blue planet in space, it could well be our ultimate salvation as a planet. Without that first breathtaking view of earth from space, followed by the disturbing information that illustrated global and environmental deterioration, we would not have the compelling public support for the environment that we are experiencing today.

These images of the "blue marble" provide us with a truly universal context in which to ponder sensorial questions on how we can direct our planet's future.

Congress is well aware of the issues that are facing our nation and our communities today concerning the under-achievement of our students in science and mathematics and the negative impact this will have on our future, if left unchecked. Hundreds of studies have documented the problems. We cannot go on assuming that our scientific and technological advancements will take care of themselves. If we are to fulfill our mission of future space science advancements, we need to assure three basic elements are firmly in place.

First, we need a qualified pool of scientists, mathematicians and engineers working in research and development. Second, we need a scientific and technologically trained work force to understand and utilize the technology of the work place. And finally, it is imperative we have a scientifically literate population. We know that without a scientific and technology education, future workers will be ill-prepared for even the most routine jobs, but even more significant, without a basic science literacy, voters will not be able to make serious decisions about urgent community and global issues.

We need to increase our science and technology education at every level. It is essential that science education begin long before students reach college. The pipeline for scientists begins not at the freshman year of college or even high school but in kindergarten. We know from research that by the end of the third grade, 50 percent of all students are no longer interested in science and only 21 percent have a positive attitude by the end of the eighth grade.

We must nurture our youth at a very early age if we hope to increase the numbers entering science and related fields.

We are especially gratified at the recent action of the House Appropriations Committee which recommended for fiscal year 1991 an increase of 12 percent funding for the National Science Foundation. In the area of science education, the Committee added a total of $34 million to the $251 million that is a part of the budget request, bringing the total to $285 million.

The science and engineering education directorate of NSF has played the leadership role in improving science education for the nation. And as you are aware, recent reorganization of the science education program, the appointment of a new assistant director for education and human resources is critical.

While the issues related to NSF are outside this Committee, I would like to provide a few comments:

There first is a need for increased interaction between education and research to enhance the collaboration between those communities. NSF's priorities need to exemplify equal importance of education and disciplinary research.

NSF must strengthen its role in leading national efforts to achieve science and mathematics student achievement goals for the year 2000 set by President Bush and the governors of the states.

And future NSF directors must have a strong commitment to education and human resource development as well as disciplinary research.

Congress is also requested to monitor the development of the programs and expenditure of resources to assure that your directives in science education, particularly at the pre-college audiences, are fulfilled.

We are also requesting that NSF appropriation for science and engineering education increase to a minimum of $600 million by fiscal year 1993, including expanded funding for pre-college and undergraduate programs.

As we strengthen our science education programs, we must understand that learning does not only take place in the classroom, there are opportunities throughout society. Across the United States, science museums are among the most popular institutions in society, reaching almost 75 million visitors annually. Established science museums are expanding at an unprecedented rate with more than $600 million of new construction or renovation currently underway.

At the St. Louis Science Center, the number of visitors has increased from 275,000 in 1985 to 886,000 in 1989. And as a result of a $34 million expansion currently under way, construction and the increased opportunity for hands-on exhibits, we expect to reach two million visitors annually by 1992.

With the construction of our new science center, we are continuing our long established commitment to space science education. The Forest Park facility which now constitutes the St. Louis Science Center, will be devoted entirely to space science. It will feature exhibits that demonstrate how pure and applied science, along with related technologies, are involved with the exploration of space. The McDonnell Star Theater, the facility that we are currently sitting in, will continue to operate, revealing the mysteries of space through the state-of-the-art Digistar equipment.

The educational opportunities we offer reach far beyond the walls of our facilities but into the schools and the community. Programs include teacher training, curriculum development, outreach to community centers and public programs such as our annual space science lecture, which this year will feature Admiral Richard Truly of NASA.

Because of the limited resources available to us, some people are questioning how we choose to support mega-science project such as the super-collider and human genome, which may be important but which also will divert money away from smaller but critical research and educational projects.

The issue of where we can gain the most benefit for our dollars, which are necessarily large in the area of space science, is an urgent one. As we plan space science projects for the next 20 years, we need to consider several questions. What space science research and development can best serve us in improving our global environment and extending the quality of life on our planet? What space science technology will enable us to continue to expand our vision and our understanding of the fragile and beautiful "blue marble?"

The importance of these questions cannot be over-estimated. Formulating them will require an educated, scientifically literate society and a leadership committed to a bright and hopeful global future. We have the capabilities and the resources to determine the correct answers. We only need to apply our will and energy to ensure that we succeed.

Thank you.

[The prepared statement of Dr. Wint follows:]

TESTIMONY

TO THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

UNITED STATES HOUSE OF REPRESENTATIVES

July 23, 1990

Submitted by

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President
St. Louis Science Center
5050 Oakland Avenue
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Subcommittee on Space Science and Applications
Testimony - Dennis M. Wint, Ph.D.
July 23, 1990

As we attempt to gauge the importance and direction of space science for the next 20 years, it is useful to consider what space science has meant to us in the past two decades. The benefits we have derived are numerous and have changed the fabric of much of our daily lives.

Our communications capabilities have expanded dramatically. Satellite technology provides us the ability to see and hear instant worldwide news coverage, whether it is an historical event such as the crumbling of the Berlin Wall, deliberations of the Economic Summit in Houston, or a tragic event such as an earthquake in the Philippines.

The factors behind atmospheric conditions, such as the solar cycle and solar winds, once beyond our scope, are now better understood, giving us the potential of accurately forecasting and preparing for the Earth's weather conditions. In addition, we have attained exciting new advances in areas such as medicine and material sciences because of spin-off technology.

Perhaps the most dramatic example of how far we have come in two decades is the way in which we understand our environment. Twenty years ago, at the first Earth Day celebration, we could only guess at the extent and seriousness of global environmental deterioration. But because of our space exploration and experience, the 1990 Earth Day celebration revealed new scientific information about the global environmental quality.

This single application of space science -- learning more about the global environment and determining by scientific methods what means must be taken to address the problems -- itself justifies our continued exploration and experimentation in space.

Because space exploration enables us to see ourselves as a beautiful but fragile "blue marble" in space, it could well be our ultimate salvation as a planet. Without that first breathtaking view of earth from space, followed by the disturbing information that illustrated global environmental deterioration, we would not have the compelling public support for environmental changes we are experiencing today.

But these images of the "blue marble" provide us with more than a view of our physical environment. The philosophical consequences of space exploration are equally profound. Humanity gains a new perspective of itself. We now have a total, truly universal context in which to ponder essential questions about how we must direct our planet's future.

Because space science is such a determining factor in our future as a planet, it is critical that the public understands its importance. Science and technology education is essential if we are to continue to advance in space during the next 20 years and beyond.

Congress is well aware of the issues facing our communities and nation concerning the under achievement of our students in science and mathematics and the negative impact this will have on our future if it is left unchecked. Hundreds of studies have documented the problems. We cannot go on assuming that our scientific and technological advancement will take care of itself. Now is the time for a concerted effort at every level of our society to improve educational programs and student performance.

If we are to fulfill our mission of future space science advancements, we need to ensure that three basic elements are firmly in place.

First, we need a substantial pool of qualified scientists, mathematicians and engineers in the work force. Science and technology cannot progress without men and women working in research and development.

Second, we need to provide adequate science, mathematics and engineering education for a trained technological work force. A large number of workers will be required to understand and utilize the technology in the workplace.

And finally, it is imperative that we have a scientifically literate public. We know that without a scientific and technology education, future workers will be ill prepared for even the most routine jobs. But even more significantly, without basic science literacy, voters will not be able to make sensible decisions about urgent community and global issues, such as waste management and global warming.

To continue our science and technology education programs, we need to continue to increase funding at every level. President Bush expressed his commitment to double the 1987 National Science Foundation (NSF) budget by 1993, and Congress has increased NSF funding for research and science education beyond the administration requests.

We are especially gratified by the recent actions of the House Appropriations Subcommittee on VA, HUD and Independent Agencies, which recommended for FY 1991 a budget increase for NSF of 12.2%. In the area of science education, the subcommittee added a total of $34 million to the $251 million budget request, bringing the total to $285 million or 39% over last year's level.

It is essential that science education begins long before students reach college. The pipeline for graduating scientists, engineers and mathematicians begins 16 or so years before, in Kindergarten. We know from research that by the end of the third grade, only 50% of the students are interested in science, and only 21% have a positive attitude by the end of the eighth grade. Obviously, we must begin to nurture our youth at a very early age if we hope to strengthen the numbers entering science and related fields.

The Science and Engineering Education (SEE) directorate of the National Science Foundation (NSF) has played the leadership role in the improvement of science education for the Nation. As you are aware, there has been a recent reorganization of the science education programs and the appointment of a new assistant director for Education and Human Resources which replaces (SEE).

I would like to take the liberty of providing comments regarding the future considerations for NSF:

1. There is a need for increased interaction between education and research and to enhance the collaboration between those communities. NSF's priorities should exemplify the equal importance of education and disciplinary research.
2. The National Science Board must strengthen its role at NSF in leading the national efforts to achieve the science and mathematics student achievement goals for the year 2000 set by President Bush and the Governors of the states.
3. Future NSF directors must have a strong commitment to education and human resource development as well as disciplinary research.

4. Congress must monitor the development of programs and the expenditure of resources to assure our directives in science education, particularly at pre-college audiences, are fulfilled.
5. The advisory committee to the Education and Human Resources directorate provide a strong advisory role to assist in the establishment of policy and program, not only with respect to the activities of the Directorate for Education and Human Resources, but in relation to all educational and human resource programs wherever located within NSF.
6. NSF increase the emphasis and support for research in assessment of successful programs for replication and for research on teaching and learning.

7. Congress is requested to increase the NSF appropriation for science and engineering education activities to a minimum of $600 million by FY 1993, including expanded funding for pre-college and undergraduate programs. The authority and responsibility for both these budget elements should lie clearly with the Assistant Director for Education and Human Resources.
8. Finally, the Assistant Director for Education and Human Resources should continue to serve as the leader for science education for other Federal, state and local agencies.

As we strengthen our science education programs, we must remember that learning does not take place only in the classroom — there are opportunities throughout our society. Science museums and educational television reach millions of people annually with programs related to science, mathematics, engineering, computers, the environment, space and technology.

As president of the St. Louis Science Center and vice president of the Association of Science-Technology Centers*, I can assure you that science museums are among the most popular institutions in society. They range from the National Air and Space Museum in Washington, D.C., the most popular museum in the world, to a developing museum in Pierre, North Dakota. More than 75 million visitors annually attend science museums programs.

Across the entire United States, established science museums are expanding at an unprecedented rate. In 40 cities, including Philadelphia, Boston, St. Louis, Louisville and Fort Lauderdale, capital projects for new construction or renovation total more than $600 million.

This expansion of science museum facilities is a direct response to the obvious enthusiasm and demand on the part of the public for interactive, engaging science and space science education. We believe it is a demand worthy of our whole-hearted support, not only from museums, but from public and governmental agencies at every level.

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* The Association of Science-Technology Centers (ASTC) has 195 science centers and museums in the United States and 58 in other countries.

It is clear that science museums have a critical role to play in space science education. Children, families and adults come to science museums because they want to, not because they are required. The support they indicate for our programs by their attendance is joined by the enthusiastic support of formal educational institutions, businesses and government.

At the St. Louis Science Center, the number of visitors has increased from 275,000 in 1985 to 886,000 in 1989. As a result of expanding our facilities now under construction and the increased opportunities for hands-on exhibits they will enable us to offer, we expect almost two million visitors by 1992.

With the construction of our new science center, we are continuing our long established commitment to space science education. The facility that now constitutes the St. Louis Science Center will be devoted entirely to space science. It will feature exhibit galleries that demonstrate how pure and applied sciences, along with related technologies, are involved in the exploration of space. The McDonnell Star Theater will continue to operate, revealing the mysteries of space through state-of-the-art Digistar equipment.

The educational opportunities we offer reach far beyond the walls of our facility into schools and the community. We assist teachers by supplying packets of curriculum ideas and activities, including a resource curriculum on space and astronomy. We have participated in a national program, Science Teacher Education at Museums (STEAM), which enables teachers to participate in science learning projects while developing hands-on activities that can be transported to the classroom.

We are working with the St. Louis Public Schools to develop a program similar to one in Buffalo, New York, where the science museum is working with the local school system to build a math and science magnet school next door. The benefits for students from this type of a learning situation could be invaluable.

While the Congress' commitment to funding scientific and space experiments is most welcome, some scientists are warning that we must rethink how we choose to spend those funds. They point out that the funding of such mega-science concepts as the superconducting supercollider and the human genome project may be useful but will divert money from many smaller but critical research projects. Still others are supportive of NASA's Mission to Planet Earth program, designed to gather precise information that will enable us to make economically and scientifically sound decisions regarding global warming and a host of other critical issues. The issue of where we can gain the most benefit for our dollars -- which necessarily are large in the area of space science -- is an urgent one. As we plan space science projects for the next 20 years, we need to consider the mega-questions: What space science research and development can serve us best in improving our global environment and extending the quality of life on our planet? What space science technology will enable us to continue to expand our vision and understanding of our fragile and beautiful "blue marble?"

The importance of those answers cannot be overestimated. Formulating them will require an informed, scientifically literate society and a leadership committed to a bright and hopeful global future. We have the capabilities and the resources to determine the correct answers. We need only to apply our will and energies to ensure that we succeed.

St. Louis Science Center

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Short Bio
Dennis M. Wint, President
St. Louis Science Center

Dr. Dennis M. Wint joined the St. Louis Science Center as President in 1986. He is also Chairman, Regional Commerce and Growth Association Museums and Performing Arts Committee; Vice President, St. Louis Area Museums Collaborative; member of the Accreditation Commission for American Association of Museums; Vice President and Chairman of the Legislative Committee of the Association of Science and Technology Centers; and has been appointed to the National Science Foundation Advisory Committee to the Directorate for Science and Engineering Education.

Dr. Wint earned his Ph.D. degree in curriculum and instruction from Case Western Reserve University, Cleveland, Ohio and his Bachelor of Science degree in wildlife management from the University of Michigan, Ann Arbor.

Prior to joining the St. Louis Science Center, Dr. Wint was Director, Cranbrook Institute of Science, Bloomfield Hills, Michigan. He was also Director of the Museum and Vice President, Academy of Natural Sciences, Philadelphia, Pennsylvania.

Mr. **Hayes**. Thank you very much.

Marty.

Dean **Israel**. Thank you very much, Mr. Chairman and members of the Committee. I appreciate the opportunity of addressing you today. I will just briefly summarize some of the remarks that are in the written testimony that you have already received.

There are three points I want to make today regarding the space science aspect of NASA's space program. The first deals with the—and I will just comment very briefly on the strategic plan that NASA's Office of Space Science and Applications has developed under the Director of that Office, Dr. Lennard Fisk. That plan is a good plan, it is the kind of plan that a nation like this that recognizes the fundamental importance of basic research and wants to maintain its competitive international leadership—it is the right kind of plan for a nation like this.

It is a plan in which Washington University has been part of for a long time. We have 19 faculty members at Washington University currently involved in over $2 million annually of research and in the last decade we have turned out nearly 40 PhD's in space science at Washington University, many of whom are working at NASA centers or in the space science program at other universities.

The strategic plan is a good one. The two points I would like to leave you with is that the universities are an absolutely essential aspect of the space program, in particular for space science, and that there are—and the final point will be that there are some problems in the relationship between federal funding agencies and universities dealing with basic research. Those are problems that are not confined only to NASA, but NASA is certainly part of it. You will hear more about that from my colleague, Professor Walker.

A point about universities. The obvious point is that universities are a training ground for the next generation of space scientists. We are dealing with a space program that has a very long time horizon. Some of the planning in the strategic program has a long-time horizon. Many of us involved in the planning will be retired when some of these things happen and it is essential that there be a new continuing stream of trained scientists who are interested in the space program and see a future for themselves in the space program. And obviously one way to do that is to continue to support the university's role in research in space.

The other point that is perhaps less obvious to people is that universities form a fertile place for interchange between those scientists involved in the space program and other scientists who are not directly involved in the space program but they are in our departments, they are down the hall from us. They give us ideas that help us with things that we have to do in the space program. A couple of examples are in my written testimony and I will not repeat them here. It also goes the other way. Universities are fertile ground for some of the spin-off things that Jim Rose talked about earlier.

I will give you an example from our own research group, my own research group at Washington University is involved in cosmic ray astrophysics. We study cosmic rays which are energetic particles from outer space that give us a sample of material from outside the solar system. Several years ago in our lab we developed a new kind of detector for cosmic rays. It is a detector that will be an essential part of a space station experiment that was recently accepted for the space station. That detector involved developing fiber optic technology and CCD camera technology to image cosmic ray tracks. We described that detector in an internal Washington University—the Washington Record, an internal newsletter that goes to faculty throughout the campus. And shortly thereafter we had a call from one of our colleagues in the Department of Radiology in the School of Medicine, who said gee, this instrument looks like it will solve some of the problems that I have in monitoring radiation therapy, cancer treatments by radiation.

One thing led to another and I can give you a long story about it, but the outcome is that there is now a small company here in St. Louis that employs 28 people and it was formed just over a year ago—it currently employs 28 people and it is manufacturing a new kind of device for real time monitoring of radiation therapy. It takes technology that we developed for our basic research cosmic ray astrophysics and applies that technology to a device that replaces x-ray film. The current way of monitoring radiation therapy is you lay an x-ray film behind the patient and after it is all over you develop the film and see where the radiation went. What we have is a real time monitor that allows in the first fraction of a second, after a fraction of a second of the radiation dose, the technologist can see on the screen precisely which organs are being irradiated and make sure that the organs that are not supposed to be, are not. And verify that in real time. It will have a major impact, I think on cancer therapy. It came about as a result—in fact some five of these have already been sold to major hospitals across the country—this came about because we had a major space research program at Washington University, we have a major medical school and the two talked to one another.

The problems with space—with support for research in space and support for basic research at universities, the federal government is progressively under-funding research at universities. As I say, this is not only NASA, it is the National Science Foundation. It used to be that the federal government would buy equipment that we need to do basic research. Now if you want to buy a piece of equipment to work on—want to buy a piece of equipment from the National Science Foundation, the university has to come up with other sources for half or two-thirds of the cost of that equipment. NASA budgets are severely constrained and so some pieces of equipment are simply purchased with other funds that the university has to come up with.

The agency used to support facilities for research. In the 1960s, NASA built some of the buildings that were needed. You do not find that in the federal government any more. Universities have to come up with that from other sources.

At the same time that the federal government is telling us that universities have to come up with some of the cost of doing this basic research that the country needs from other sources, we have other parts of the federal government and the public saying why do you people charge so much tuition? Why do you not use your endowment to support the students instead of charging tuition? Well gentlemen, we have to come up with the money from somewhere and if the federal government, through the science agencies, will not support the basic research, where are we supposed to go? I do not think we should charge the parents of our tuition-paying students for the basic research that the whole country needs. And so I think it is a problem with NASA support of basic research, it is a problem with NSF support, it is a general problem with federal support of basic research. I think it is short-sighted if the federal government does not give universities the real cost of doing this research and keeping us competitive with the rest of the world.

And I will conclude and let you hear—give you time to hear from Professor Walker.

[The prepared statement of Dean Israel follows:]

Testimony at the Field Hearing of the
Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
U.S. House of Representatives

St. Louis, Missouri, July 23, 1990

Martin H. Israel
Professor of Physics
Dean of the Faculty of Arts and Sciences
Washington University in St. Louis

Thank you for inviting me to testify on the future of our nation's space program. I wish to make three points today: First, NASA's strategic plan for space science is a good one that deserves strong support from the Congress and the nation. Second, universities play an essential role in the space program; their active involvement benefits both the space program and the nation as a whole. Third, there are problems with both the level and the form of NASA support for university-based space science; I will make some remarks on this third point, and you will hear more about it from my colleague, Professor Robert Walker.

BACKGROUND

I address you today both as a space scientist and as an administrator of a university that is actively involved in NASA's space science programs.

Since becoming a professor at Washington University in 1968, I have been a principal investigator for cosmic-ray experiments including instruments built at the university and flown on stratospheric balloons and an instrument in earth orbit on NASA's third High Energy Astronomy Observatory.

Since 1987 I have also been Dean of the Faculty of Arts and Sciences. As such I am concerned with Washington University's role in teaching undergraduate and graduate students and our role as one of the nation's major research universities.

We have a long tradition of involvement in NASA's space science program. Currently the 19 faculty members in Washington University's McDonnell Center for the Space Sciences have approximately $2-million annually in NASA research grants and contracts. We are actively involved in the Magellan mission to Venus, the Mars Observer, and planning for two of the instruments that were selected as attached payloads for the early phases of Space Station Freedom. We have been designated as the Geoscience Node of NASA's Planetary Data System. We are engaged in basic research supported by several of NASA's Research and Analysis programs.

In the past ten years forty of our students have received Ph.D. degrees in space science. Many of our graduates are now research scientists at NASA centers or participate in the nation's space program in faculty or research positions at universities.

NASA'S STRATEGIC PLAN FOR SPACE SCIENCE

Dr. Lennard Fisk, NASA's Associate Administrator for Space Science and Applications, has put in place an excellent strategic plan that balances major spaceflight missions, smaller missions, and support of the research base. It is an appropriate plan for a nation that recognizes the fundamental importance of basic research, a nation that wishes to maintain its competitive international leadership in a technological world, a nation that seeks answers to fundamental questions about the planet on which we live and universe around us.

Spacecraft launched in the past year promise major advances in our understanding of phenomena as near as Venus and as distant as the Big Bang with which the universe began. On August 10, less than three weeks from now, the Magellan spacecraft will go into orbit about Venus to provide detailed radar images of the surface of this planet which is physically so similar to the Earth but offers an environment so different. Meanwhile, the Cosmic Background Explorer is in orbit returning data of unprecedented scope and precision on the omnipresent remnant radiation from the Big Bang.

The Hubble Space Telescope has attracted attention during the past few weeks because of what it has not achieved, but we should remember that it is still by far the best ultraviolet telescope ever made. Even before the optical corrections are made three years from now, it will be capable of a host of important new ultraviolet and spectroscopic observations.

The strategic plan calls for four great observatories, of which Hubble is the first, spanning the electromagnetic spectrum to provide an integrated picture of our universe that is attainable only with instruments outside our atmosphere. The plan calls for a series of planetary missions that will greatly improve our understanding of the solar system, and thus can have profound influence on our understanding of the Earth. It calls for a series of earth-orbiting spacecraft in a "Mission to Planet Earth" that will provide the global overview of our planet that is essential to understanding and protecting our environment. And the plan provides for solar and space physics instruments that will answer vital questions about the Sun and the interplanetary medium. These missions are the result of extensive study and debate within the scientific community. They represent logical and important steps in improving our understanding of our environment and our universe.

An absolutely essential aspect of the strategic plan, which receives relatively little public attention, is the research base. To quote from the 1990 Strategic Plan:

> The research and analysis program provides base support for a vigorous and productive research community, and it presents a special opportunity for students to develop the skills that will enable them to conduct the programs of the future.

While NASA's Strategic Plan for space science is a good one, there are problems with its budget implementation. The planned level of funding for data analysis is inadequate for the enormous increases in quantity of data that the program will produce. Funding, in particular, for support of university-based research is not adequate to provide the flow of new scientists that the program will require and to maintain the research groups upon which the program depends.

THE IMPORTANCE OF UNIVERSITIES IN THE SPACE PROGRAM

Universities are the training ground for future space scientists, and having graduate students involved in NASA-sponsored research is an excellent way to bring them into the program. The long-term success of the strategic plan depends upon a flow of new space scientists. NASA recognizes this fact with its Graduate Student Fellowship program.

Universities also provide a broad education for undergraduate students, and it is important to the nation that the college-educated population understand and appreciate the contributions of the space program. When a professor who is involved in NASA programs teaches a general astronomy course for non-science students, he or she cannot help but convey the significance and excitement of the space program.

Universities provide a fertile ground for interaction between scientists who are involved in the space program and others who are not. At universities ideas from outside can easily enter and support the space program, and developments from within the space program can easily be communicated to those outside the program. I would like to give you a few specific examples from my own experience at Washington University.

When I began developing ionization chambers for the cosmic-ray detector that eventually flew on the HEAO-3 spacecraft I had help from another professor in the physics department Arthur Hughes. Hughes had never been involved the space program, but he took an interest in my work and gave me useful advice from his own experience.

Just a few weeks ago, when the Hubble problems came into the news, a professor in our cosmic-ray group remembered a physics colloquium a few years ago. One of our departmental colleagues, Professor Ed Jaynes, had described his maximum-entropy technique for deriving sharp images from blurred pictures. We are hopeful that this computerized technique will permit recovery of some of the image quality that has been lost by Hubble's spherical aberration.

As an example of how universities facilitate the application of NASA-program developments to problems outside the space program I would like to describe the development of a new device being used in cancer therapy. In our research group several years ago we developed a new kind of cosmic-ray detector that utilized scintillating fiber optics and imaging devices similar to those used in TV mini-cameras.

About five years ago a faculty member of our Washington University Medical School read about our new cosmic-ray detector in an internal university newsletter. He recognized that this kind of device could solve problems he had encountered in monitoring radiation therapy. My cosmic-ray colleagues and I collaborated with him to design an imaging device that gives real-time monitoring of radiation therapy. It can replace x-ray film which records the radiation exposure but can be studied only after the fact. The new device thus promises greater precision in targeting therapeutic radiation.

A little over a year ago a new company was established here in St. Louis to manufacture and market these therapy-monitoring devices. Fiber Imaging Inc. currently employs 28 people; it has already delivered five of these new instruments to major hospitals around the country.

PROBLEMS IN NASA SUPPORT OF UNIVERSITY RESEARCH

NASA support of research at universities can be broadly divided into two types. First, there are contracts for development of specific instruments or for specific data analysis programs associated with individual space-flight missions. Second, there are grants from NASA's Research and Analysis (R&A) budget lines for ongoing programs of basic research. These R&A grant programs lead to new knowledge essential to our understanding of space phenomena and to new kinds of instruments or research techniques that may become parts of future space-flight missions. I will confine my remarks to the second of these types of support, the R&A budget.

Much of the training of graduate students occurs in the R&A program where projects tend to be of smaller magnitude and shorter duration than space-flight missions. R&A programs also can provide the stable base of support that university research groups require to maintain key technical staffs and develop ideas for future space-flight programs. While taking up a relatively small part of the overall NASA budget, R&A programs are responsible, directly or indirectly, for a large fraction of the scientific results of the space program.

Over the past fifteen years, however, support for R&A programs, adjusted for inflation, has slowly but steadily shrunk until today we find ourselves with funding that is not sufficient for a strong research program. Funding is very inadequate for purchase of new instrumentation. Funding is non-existent for research facilities, which NASA showed great foresight in supporting in the 1960s. University scientists find themselves spending more and more time seeking a multitude of smaller research grants in order to sustain their research capability, rather than devoting time to research.

I see two reasons for the problems with R&A funding. One is part of a larger national problem of inadequate funding for scientific research, and the other is a problem unique to NASA.

The general problem is a federal government that is progressively underfunding research at universities. Government agencies are expecting universities to bear an increasing share of the support of basic research. The National Science Foundation now supports the purchase of research equipment only if the university will pay from "other sources" half or more of the cost. NASA squeezes R&A budgets until some equipment must be bought completely with funds from "other sources". Agency support of faculty salaries used to be close to commensurate with the time they devote to the research, but that support now is drastically reduced or in many cases non-existent; universities are expected to pay those salaries from "other sources". Salaries for technical personnel to support research groups are being cut from grants; let the universities pay for those salaries from "other sources".

But where are those "other sources" from which universities are to pay these real costs of research? Some corporate support has been very helpful, but corporations have to look to direct impact on their own programs, not to long range benefits to the nation of basic research. Some foundations have been helpful, but they tend to make one-time gifts to initiate a new program, expecting that ongoing support will come from other sources. That leaves the income from the universities' endowments or from tuition. But there is increasing complaint from many quarters, including parts of the federal government, that private universities charge too much tuition. We should cut costs, and we should use our endowment and gift income in such a way that we can hold down tuition. How then, can universities support basic research if the federal government does not pay the real costs?

We cannot expect the parents of our tuition-paying students to pay for the basic research needed by our entire nation. This nation needs a healthy university research base if we are to maintain our stature in a competitive technological world. This research base is important to the entire nation, and should be paid for by the entire nation through the federal government.

There is a second problem with R&A funding that is unique to NASA. The flight programs of NASA are often started with inadequate contingency funds. When funding gets tight, either because of unexpected problems in a flight program, or because of cuts imposed on NASA by across-the-board budget reductions such as sequestration, the flight programs cannot accommodate the cuts without very costly flight delays. The result has frequently been that the R&A programs suffer a grossly disproportionate share of budget cuts.

The health of the nation's space program and the ability of universities to participate in this program requires a major increase in NASA's R&A funding. Dr. Fisk recognizes this need, and he is considering requesting for FY92 a "new start" for the R&A program. Under this plan, a major budget increment for R&A would take the priority that is usually reserved for the start of a new space-flight mission. I strongly support this idea of a "new start" for R&A, and I urge this committee to give R&A

funding the priority it deserves in future planning for NASA.

Conclusion

The NASA space science program has good plans that can lead to major scientific results over the next decade or two. University-based research is essential to the success of those plans. Adequate support of university research requires a significant increase in NASA's R&A funding, as well as sufficient contingencies in NASA's flight programs so that the R&A programs do not absorb a disproportionate share of NASA funding problems.

CURRICULUM VITAE

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Born: January 12, 1941, Chicago, Illinois

Education: S.B. - University of Chicago, 1962
Ph.D. - California Institute of Technology, 1969

Professional Experience:

1968-1972	Assistant Professor of Physics, Washington University
1972-1975	Associate Professor of Physics, Washington University
1975-present	Professor of Physics, Washington University
1979-1980	Visiting Associate, California Institute of Technology
1982-1987	Associate Director, McDonnell Center for the Space Sciences, Washington University
1987-1988	Acting Dean, Faculty of Arts and Sciences, Washington University
1988-present	Dean, Faculty of Arts and Sciences, Washington University

Scientific Work: Cosmic-Ray Astrophysics

Elemental and isotopic composition of heavy cosmic rays; energy spectra of individual elements. Astrophysical implications regarding interstellar medium, supernovae, and nucleosynthesis.

Principal Investigator for the Heavy Nuclei Experiment on the third High Energy Astronomy

	Observatory (HEAO-3), which measured elemental composition of nuclei heavier than iron. Principal Investigator for several balloon-borne detector systems which measured composition and energy spectra of heavy cosmic rays.
Professional Societies:	American Physical Society, Fellow American Astronomical Society American Association of University Professors American Association for the Advancement of Science
National Committees:	Radiobiological Advisory Panel, Space Science Board (NAS-NRC), 1971-1973 Balloon Study Panel, Geophysics Research Board (NAS-NRC), 1974-1975 Bevalac Users Group Executive Committee, 1974-1975; Chairman, 1975 Committee on Space Astronomy and Astrophysics, Space Science Board (NAS-NRC), 1976-1979 High Energy Astrophysics Management Operations Working Group (NASA), 1976-1984 Division of Cosmic Physics, American Physical Society, Executive Committee, 1975-1977; Vice Chairman, 1979-1980; Chairman, 1980-1981 Cosmic-Ray Program Working Group (NASA), Co-Chairman, 1980-1982; 1984-1985; 1987 High Energy Astrophysics Division, American Astronomical Society, Executive Committee, 1982-1984 Space Science Working Group (Association of American Universities), Chairman, 1983-1985, Steering Committee, 1985-1988 National Organizing Committee for the 19th International Cosmic Ray Conference, Chairman, 1982-1985 Sub-Panel for Cosmic Rays and Sub-Panel for Space and Astrophysical Plasmas, Physics Survey Committee (NAS-NRC), 1983-1984 Space and Earth Sciences Advisory Committee (NASA), 1985-1988 Particle Astrophysics Magnet Facility Definition Team (NASA), Chairman, 1985-1987 Astrophysics Council (NASA) 1986-1987

University Committees:	Field Studies Committee (College of Arts and Sciences, 1971-1973 Assembly Series Board, 1972-1974 Advisory Committee on Personnel (Faculty of Arts and Sciences) 1983-1986 Search Committee for Dean of the Faculty of Arts and Sciences, Chairman, 1983-1984 Educational Policy Committee (Board of Trustees), Faculty Representative, 1983-1985 Search Committee for Chairman of the Department of Chemistry, 1984-1985 Academic Planning Committee (Faculty of Arts and Sciences) 1985-1987
Honors and Awards:	Alfred P. Sloan Fellow, 1970-1972 NASA Exceptional Scientific Achievement Award, 1980 Elected Fellow of the American Physical Society, 1984

Mr. **Hayes**. Thank you.

Dr. Walker.

Dr. **Walker**. Thank you, Mr. Chairman. I will just simply summarize the major points of the written testimony in view of the time.

(1) We have much to be proud of, of course, in the past accomplishments in space science. The discoveries of the past three decades have opened up an enormously interesting future for the next generation.

(2) Space science is alive and well in St. Louis. And I will give you an example from my own laboratory.

(3) However—and this is the main thrust of my testimony—there are severe problems. What was once a powerful and productive partnership between NASA and the universities has hit a low point. NASA is not now and has not been for some time doing a proper job of "preserving a vital and productive research base", as stated in their overall science plan.

(4) Re-establishment of the previous partnership is absolutely essential for the future. Missions and indeed practical applications are based on the work of university groups working in basic research.

What can be done? I will return to this at the end. Suffice to say here at the beginning that I will not ask for massive new science starts. I will and so ask for your support of the research and analysis of line items in the science budget.

Anyway, let me talk about what is going on right here in St. Louis. I am a university professor, you are a captive audience, we will have a two-minute—sorry about that—the first slide—I pushed the button, I was told the slide would—that is the second slide, but never mind, we will start with this one.

Mr. **Volkmer**. Is it that big?

Dr. **Walker**. Actually it is totally out of proportion. It looks like a big fuzzy ball, it is out of focus. Can you focus it better? Anyway, this is a little grain removed from a meteorite. In fact, this grain is so small you cannot see it with the naked eye. It appears as kind of a little dot in the most powerful optical microscope, if you looked at it, and this is a highly expanded version, magnified version, taken in an electron microscope. This is a little sample of a common mineral called graphite. Now graphite is very common, lead pencils. It does not, however, normally occur in this form.

Oops, that is surely not my slide.

Mr. **Volkmer**. It is pretty.

[Laughter.]

Dr. **Walker**. There we go. That kind of cracked thing in the center was supposed to be the first slide. That is a little grain of silicon carbide. It is one-ten thousandth of an inch across. Silicon carbide you know about of course, emery paper, but it is actually a very rare mineral in nature and very rare in this meteorite, only a part per million.

Now why do I bother to show you pictures of little grains of silicon carbide and graphite that you cannot even see with your naked eye? The answer is that they represent—may we have the lights please? They represent an important scientific discovery made with an instrument, by the way, that was purchased by a gift from Mr.

McDonnell, it was the last gift he gave us before his passing away. Those little grains are the first solid grains of material ever found that were not formed in our solar system—unique in our experience. These are grains that were formed around distant stars before the solar system existed.

Now why we think that is true is spelled out in more detail in the testimony. I do not have the time to go into it. I do remark we were able to prove that to our own satisfaction as well as others because of the instrumentation that was given to us as a gift by Mr. McDonnell. We expect the continued study of these grains will lead to a better understanding of the evolution of stars, since they come from other stars, and how the chemical elements of which we are all composed, were originally formed. You were once parts of stars.

Now let me—

Mr. HAYES. I have a lot of colleagues that confuse their present status with that too.

[Laughter.]

Dr. WALKER. Well some stars are prettier than others—some stars are quite ugly actually.

Okay, let me leave the science and talk about more immediate problems. I have asserted that the science base, space science, in universities has been eroding in recent years. Attached to the testimony are charts that document the situation and statements and so forth. And to show you that it is not just me and my colleagues at Wash U. that are complaining, there are also attached statements from other people, including from the State of Arizona.

Now, I am speaking—and my colleagues, when I speak for my colleagues, we are speaking as winners in peer reviewed competitions. It is a tough life for a scientist, it is a highly competitive business, but we win the competitions. And if we are having all these problems as winners, God help the losers.

Now what should be done? What am I asking you people to do? Support and increase the R&A, the research and analysis, line items. Protect the R&A university funding from raids. Typically we get a budget from NASA administrators and then there is a call saying there is a tax on the R&A program, your budget goes down. There is another tax, another phone call. It is a dismaying business and makes it almost impossible to plan. Make sure that adequate contingency funding is built into any new starts. Make sure, particularly with big programs like earth observation, that adequate funding is provided for data analysis. That would provide an enormous amount of data analysis.

And finally, I am asking, and it is described more fully in the written testimony and I shall not describe it here in detail, for you to consider re-instituting a program of sustaining grants at selected universities chosen competitively. This program would permit us to make rapid decisions in real time at the local level. It would be a small part of the total research funding but it is enormously effective money.

I reiterate, I am not calling for massive new starts. The R&A budget is a small fraction of the total science budget. It is, however, my understanding that Dr. Lennard Fisk, the associate administrator for Space Science and Applications is considering proposing an injection of funds into basic research groups simply to bring them back up from the sorry level at which they currently exist, as the equivalent of a new start for the next year. This step is a crucial one. I can think of nothing that would be better for the future of space science in this country, and if it is proposed, I would hope that it would have your support.

Thank you.

[The prepared statement of Dr. Walker follows:]

SPACE SCIENCE AND THE UNIVERSITIES: A FALTERING PARTNERSHIP

Robert M. Walker
McDonnell Professor and Director
McDonnell Center for the Space Sciences
Physics Department
Washington University
St. Louis, Missouri

Before The
Subcommittee on
Space Science and Applications

Monday, July 23, 1990, 9:a.m. - 1:00 p.m.
St. Louis Science Center
St. Louis, Missouri

INTRODUCTION

Thank you for inviting me to speak today on a subject that is close to my heart. I speak partly as the Director of the McDonnell Center for the Space Sciences at Washington University. Founded in 1974 through the generosity of the late James S. McDonnell, the Center consists of some 20 faculty members distributed in several academic departments, an additional 12 postdoctoral researchers, as well as students and staff totalling some 76 individuals (see attachment A). However I also speak as an individual university scientist who has been involved in various aspects of space science for over 25 years. In this capacity I am the Principal Investigator (PI) on a grant from the Planetary Materials and Geochemistry Program at NASA, the Co-PI on a cosmic dust experiment that was returned to earth aboard the Long Duration Exposure Facility (LDEF) in January of this year, and the PI on an experiment chosen last year to be one of the first attached science payloads on Space Station Freedom. Finally, I speak as an educator who interacts with students at various levels ranging from groups of grade school children who periodically tour our laboratory, to freshmen enrolled in introductory courses, to graduate students with whom I work daily on specific research projects.

IMPORTANCE OF SPACE SCIENCE

With this background you will hardly be surprised to learn that I am a strong supporter of the space program and of space science in particular. I happen to believe that the future of the human race lies beyond this planet. It has been my extraordinary good fortune and privilege to participate in the intellectual revolution of the past several decades as we have first ventured into space.

I also see much that is encouraging in the present situation. After the difficult days following the Challenger disaster, the Galileo and Magellan missions are on their way and there are a set of other splendid missions in various stages of planning and development. The Associate Administrator of the Office of Space Sciences and Applications for NASA, Dr. Lennard Fisk, and the agency as a whole deserve a great deal of credit for the present situation.

The recent problems with Hubble should not overshadow the positive accomplishments of the last several years. Although I have no direct contact with the program I know that everyone involved, especially the scientists themselves , feel wretched at the current difficulties. However, the effort is far from a total loss and I expect that those involved will be able to resolve most of the problems before it is over.

3

THE INTERPLAY BETWEEN MISSIONS AND FUNDAMENTAL SCIENCE: THE RECENT DISCOVERY OF INTERSTELLAR GRAINS AS A CASE IN POINT

The marvelous space missions of the last decades such as Voyager and Viking, have allowed all of us, scientist and ordinary citizen alike, to share in the excitement of discovery. It must be realized however that the missions themselves are only the tip of a pyramid of interrelated activities. The choice of scientific objectives, the decisions as to which instruments to fly, and the interpretation of the results of various measurements all rest on a broad base of fundamental knowledge. This base is generated in ground based activities that span the range from laboratory measurements to theoretical work on the fundamental properties of matter. Flying good missions requires a continual interplay between ground based work and that done in space. I would like to give you a specific example from some recent work in our own laboratory.

First a bit of background. There are 92 naturally occurring chemical elements and about five times as many different isotopes. Since about the mid-fifties scientists have believed that almost all of these isotopes must have been produced inside of stars. Once produced, they escaped from the stars either in the form of individual atoms or as grains of dust. These interstellar atoms and dust grains suffer a variety of fates but some end up in interstellar gas-dust clouds. When a given cloud becomes sufficiently dense it undergoes gravitational collapse and new stars are formed. This is what we believe happened some 4.60 billion years ago in the formation of our own solar system. It is not the least bit fanciful to say that everyone, or more precisely the atoms of which everyone is composed, were once parts of different stars.

It used to be believed that the formation of the solar system was such a violent process that everything, including the interstellar dust that was there before the collapse started, had gotten extremely hot. So hot in fact that all the dust vaporized and the resultant gas had gotten thoroughly mixed. This explained why, to a first approximation, the relative abundances of various isotopes in terrestrial rocks, lunar rocks and meteorites are all the same. Fortunately, we now know that not all of the original interstellar dust was destroyed -- some of it did survive and it can be isolated and studied in the laboratory.

I have appended to this testimony photographs made in our laboratory showing small grains of silicon carbide imbedded in a primitive meteorite and small grains of graphite found in an acid residue from the same meteorite (attachment B). These tiny objects, which are invisible to the naked eye and only barely visible as small dots in the most powerful optical microscope, are grains of interstellar dust that formed around distant stars before the solar system formed. How do we know this? Simply because the isotopic compositions of the elements in these grains are totally different than anything else that has ever been seen. This is the first time that such material has been available and we expect that continuing study of the dust will provide new insights into how the elements were formed and stars evolved.

The relevance to space missions is several-fold. Most of the laboratories that work in this field are those that investigated the first lunar samples. In this country they are supported by the Planetary Materials and Geochemistry Program of NASA. These same laboratories are those that will be called on in future space missions to the moon, Mars (many scientists believe that certain non-primitive meteorites are fragments of Mars), asteroids (where most meteorites are thought to originate), and to comets. The discovery of interstellar grains gives strong scientific justification for comet missions since comets are widely believed to be the most primitive bodies in the solar system and thus, the ones most likely to contain an abundance of interstellar grains.

SERIOUS PROBLEMS FOR UNIVERSITY-BASED SPACE SCIENCE

Although I have never been more excited about space science as a discipline than I am at this moment, and while I commend the agency for the advances of the last several years, I must also tell you, sadly and reluctantly, that from my viewpoint the relationship between universities and NASA is the worst since the agency was formed. University space scientists are facing a crisis which if not soon resolved will destroy the scientific base needed to fly future missions and to provide the young talent needed to keep our country in a pre-eminent position into the next century.

Attached to this testimony is a letter written to Dr. Lennard Fisk earlier this year by some of us at Washington University (attachment C). Here I wish only to read the part of the letter that states the problem as we see it.

> STATEMENT OF THE PROBLEM:
>
> There are several reasons why it has become increasingly difficult for us to make rational plans for the future, or even to continue our normal work with NASA:
>
> a) Funding for our basic research programs has not kept pace with inflation for many years.
>
> b) Although we succeed in peer-reviewed competitions, there is continuing uncertainty on the levels of support that we will actually receive. Initial announced awards are frequently reduced without warning at least once, and sometime more than once, before a real number is given.
>
> c) Even after supposedly final figures are given (frequently after the renewal dates have already passed) the money is held up for long periods of time before it arrives at the university. During this long, uncertain period research groups operate with advanced authorizations from the university, but there is never complete assurance that the money will ultimately arrive.
>
> d) Funding to cover new initiatives (e.g. analysis of LDEF, now that it has returned to earth, or to work on attached payloads selected for Space Station) has not materialized.

Coping with the above conditions has created a situation where we are keenly aware that we are accomplishing less and less productive work as time goes on. We are not working fewer hours; rather our talents and energies are being increasingly dissipated. Some of us are becoming increasingly linked to other funding agencies, taking on other duties (e.g.: service work), doing more administration, and, in general, trying to perform an increasingly complex balancing act to preserve our basic research groups.. Difficult to quantify, but real, is the emotional wear and tear on creative individuals as a consequence of this state of affairs.

It is also demoralizing to see the future being mortgaged. We all know capable young people who could contribute to NASA's goals (some of them our present or former students) who simply cannot break into the system. And why should they? They see what we have to go through and our frustration must communicate itself to the young. Indeed, the advice that some of us give to our students is that although space science is intellectually exciting, they should plan to continue work in the field only if they go into it with their eyes wide open, realizing the increasing difficulties they are likely to face in trying to work with NASA.

Those of us who have been linked to the NASA enterprise for many years believe that the current situation represents a serious deterioration in what has traditionally been a productive partnership between NASA and university scientists.

To document some of the assertions made above, I have attached a section labelled, "History of Funding for the Planetary materials and Geochemistry Program" (attachment D). The first page shows that the bulk of the money in this program goes to universities -- it is the lifeblood of my own research group and others at Washington University. The second page shows the decline in funding of this program in recent years and the final page shows the parallel pattern in other university- linked science programs supported by NASA.

Although the funding charts I have shown start in 1984, this does not imply that the problem started then. In fact 1984 was not a particularly good year; funding for many of the basic research groups had been decreasing for years prior to that. Some of this decrease was inevitable and even desirable as lunar sample studies evolved from the initial first-order investigations to deeper and more sustained studies. However, as I attempted to show from my brief discussion of the discovery of interstellar grains, the study of extraterrestrial materials has continued to produce exciting scientific results. The point of reasonable attrition was passed a long time ago.

One insidious effect of the long and demoralizing decline in support is an almost unconscious switch in thinking. We should be talking about the new ways in which we could approach the scientific challenges; instead, I find myself asking here simply to restore an older status quo and maintain what we already have. Certainly that is the first order of business. It takes years of intense effort to build up a first-rate research group and only a single adverse administrative decision to destroy it. However well equipped, a laboratory is only as good as the people in it. Make no mistake about it, good scientific talent is rare; if good people leave they cannot be replaced.

And what of the younger generation? I was lucky enough to come to the university at a time when it was possible to act on dreams and establish a new laboratory. At this point in time the few young people who are added to this field think in terms of modest funding and association with already established groups. Would I have chosen this field of work given the current boundary conditions? I doubt it. Yet the future of space science depends on attracting the very best young scientists to the field. Frankly, I think that we are in trouble.

The dissatisfaction that we have expressed is felt throughout the space science community. To demonstrate this I have also included in this testimony several recent statements by other scientists (attachments E and F). University groups engaged in long-range, fundamental space science research are hurting terribly.

THE SPECIAL PROBLEM OF LABORATORY INSTRUMENTATION

Experimental scientists need state-of-the art instrumentation. Unfortunately, many NASA-supported laboratories are working with aging and outmoded equipment, some of it dating back to the Apollo days and even before. This is a general problem in American research laboratories, but it is especially bad in those laboratories working in space science. In the extraterrestrial materials field the pace of laboratory improvment has been much higher in Western Europe than in the United States, leading to a steady deterioration in our ability to compete on the world scene. The instrumentation problem is discussed in detail in a recent report by a NASA advisory committee titled, "Advanced Analytical Facilities" excerpts from which are included as part of this testimony (attachment G).

In contrast with many U.S. laboratories, we have excellent analytical facilities at Washington University. This is because we have been blessed with generous private donors and a farsighted and supportive university administration. The discovery of interstellar grains that I described earlier would simply not have been possible if we had relied on the government to provide modern instrumentation. Although most of our equipment has been purchased with private funds, we make it a policy to collaborate liberally with other investigators; a steady stream of visitors from other universities insures that the equipment is used to maximum advantage.

Before leaving the subject, I would like to remark that I consider the sad state of science instrumentation to be a serious national problem that deserves the special attention of this committee in future hearings. The problem is far more complex than just replacing worn out machines. New instruments embody new concepts, are inherently more expensive to maintain, and require highly trained personnel to use them. I do not consider it accidental that many of the most advanced instruments for material analysis are developed and manufactured abroad; changes in the way we approach this question could improve the current unsatisfactory situation.

INCREASED BUREAUCRACY

Although it is difficult to quantify, I also want to share with you my perception that NASA is becoming an increasingly bureaucratic organization. Let me cite just two examples. LDEF returned to earth in January of this year. Money that had been promised us to analyze our experiment was sent from headquarters to Langley, which administers the project, on April 1. We have not received any of this money and are currently running a substantial deficit at the university. After considerable administrative backing and hauling, I was told earlier this month that we would have to start the paper work from scratch and that many additional months would elapse before receipt of funding. Right now I am deeply worried that the money will not appear before the end of the fiscal year and will be lost. This is precisely what happened last year with funding that had been promised us to prepare for the LDEF return. That money never materialized and the resulting deficit had to be paid from the private resources of the McDonnell Center for the Space Sciences.

A second example is our continuing nightmare with space station funding. Last year about this time, I was notified that I had been selected as principal investigator on an experiment which would be one of the first attached payloads on Space Station Freedom. After total silence for many months, I was told in early February that we would receive "token" funding this year (8% of what we had requested). The money was already at the Johnson Space Center and we were informed that we would receive it shortly. To date we have received no money, token or otherwise. Submission of a modified budget and repeated letters and phone calls have been to no avail. My co-investigator at the University of Chicago, the distinguished space scientist Prof. John Simpson, now tells me that he may have to disband the basic research team that makes his part of the experiment possible! These, and other administrative hassles with NASA are making it difficult for us to get our work done. The current attitude within the agency is a very far cry from the can-do philosophy that characterized NASA in the Apollo days.

You are in a better position to judge whether the problem of increasing bureaucracy is unique to NASA or whether it is a general problem with government agencies. I do know that it makes it very difficult for me to advise young scientists to pursue careers in space science.

WHAT SHOULD BE DONE

The most fundamental need is to have the agency, and the Congress, give higher priority to NASA's stated goal of "ensuring a vital and productive research base." Specifically, I ask the committee to take the following actions:

1) Support and substantially increase the R and A line items in the science budget. These are the parts of the budget that fund university groups.
2) Ensure that R and A funds slated for the basic support of university groups are somehow "fenced off" to prevent continual raids on this money to cover cost overruns in other programs.

3) A corollary to this is to make sure that new missions or other new starts have sufficient contingency funding built into the programs.

4) Ensure that R and A funds are commensurate with the complexity and volume of data expected from future missions. For example, Magellan, Mars Observer, Galileo, CRAF, and Cassini will each acquire a terabit (thousand billion bits) of data. The Earth Observing System will acquire that amount of data in a day or so. These volumes far exceed the amount of existing data and substantial increases in R and A will be required to use the information.

5) Reinstitute a previous very successful program of "Sustaining Grants" to universities.

The agency is aware of the crisis in university funding. It is my understanding that NASA's Space Science and Applications Advisory Committee (SSAAC) is currently reviewing the needs of the R and A line item at the request of NASA's advisory committee. SSAAC has been on record supporting R and A funding many times in the past, but this current initiative is apparently an in-depth analysis of the erosion of basic research capabilities caused by the policies of recent years.

I have also been informed that Dr. Lennard Fisk is considering proposing increased R and A funding as the equivalent of a "new start" in the FY 92 budget. This would not be done to create a new program but simply to recoup the losses that the university community has suffered in the past. I can think of no action that would be better for the long range health of space science in this country. If proposed, I hope that it will be of a magnitude and scope to redress the current state of affairs. And if it is, I would hope that it would have the strong support of this committee.

Unlike missions which have a finite lifetime, R and A budgets need continuing commitment to ensure a sustained, viable basic research program.

Those of us who have chosen space science as a career are in it for the long haul. We welcome competition and peer review; when we succeed we hope that we will be able to continue our work.

You will note that I have not called for any massive new starts. Rather, I have simply asked for a continuing level of support that will allow good research groups, subject to peer review control, to function normally without the continual necessity of finding new sources of support to maintain their basic research groups.

INSTITUTIONAL SUPPORT

I have also called for a return to a program of "sustaining support" for universities. Let me explain. In the early days of NASA there was a program with this name that provided modest funds to a large number of universities. As time went on the number of universities receiving general support under this program declined and it was ultimately abolished.

In its place an "Innovative Research Program" was established. Under this program Washington University received a small but significant ($120K) amount of funding each year. Although the amount represented only some 6% of the total NASA research funding for different research groups at our university, the money had a disproportionate impact on our research productivity. This is because we used the money to stimulate imaginative, new efforts (particularly by junior faculty and research associates), whose final success could not be guaranteed ahead of time. Naturally, we had to rigorously account for the money at the end of each year. This "seed funding" produced a substantial number of successful projects that have influenced NASA and the country as a whole in a variety of ways. For example, the two space station projects for which scientists at Washington University were subsequently selected were a direct result of this funding. Moreover, one of the projects involving scintillating optical fibers has proved to have important medical applications and a private company has been spawned to pursue this aspect of the work. Many other examples could be cited.

However at the time of the last renewal application, we were told that institutional support was no longer considered appropriate; henceforth Innovative Grants would be given only for individual projects. I have been further assured by a number of people that the Congress frowns heavily on such institutional grants and that I am being politically naive to discuss the subject at this hearing.

Why? Surely in 1990 it is obvious that localized decision making has merit compared to central planning. What I propose is a competitive program to provide institutional support to universities where there are concentrations of scientific talent. The money would be spent promoting basic research in the space sciences at each institution, but the specific projects to be supported would not be spelled out ahead of time. Instead the performance of each university would be reviewed annually to ensure that the funds were being used for the intended purposes. Why not?

I am not suggesting a retreat from the current system of peer review. In common with most university scientists, I believe that the present system, where individual proposals are reviewed for their scientific merits, is the best one available to make sure that limited funds are used most productively. Most funding for university researchers should continue to be allocated this way. However, we need to modify the current system to allow for more local control and decision making and to allow for rapid exploitation of new ideas in a way that is not now done. Perhaps the amount of institutional funding could be tied directly to the success of peer reviewed work by fixing the amount at a small percentage (5 to 10%) of the total NASA research funding received by the universities. And, in my view, such a system should not be restricted to NASA, but should be instituted across the board for all science funding by federal agencies.

FINAL REMARKS

NASA "bashing" seems to have become fairly popular in recent days; indeed, my testimony could be interpreted as adding still another voice to this already large chorus. This is not my intent. In my view, NASA has accomplished more of substance than any other government agency in the years since its establishment. The opening up of space will be remembered long after many of our current, pressing problems have been forgotten. As an American I am proud of NASA and its accomplishments and profoundly grateful that I had the chance to participate in its great work.

NASA accomplished so much because it harnessed the imagination and energy of a broad cross-section of our populace, scientist and citizen alike. Breathtaking vistas have been opened up and I want my children and my children's children to explore them. I want to encourage young people to devote their lives to space science. I want them to share the joys of discovery. I want them to participate in this noble enterprise.

So I think do you, and so I think do the dedicated people of NASA. If there are problems- and there are- let us identify them, let us solve them, and let us get back to the joint work at hand.

Thank you for this opportunity to present my views.

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Washington University
McDonnell Center for the Space Sciences
St. Louis, Missouri 63130

I. INTRODUCTION

This report covers the period September 1, 1988 through August 31, 1989. The McDonnell Center for the Space Sciences at Washington University is an interdepartmental research center. Its faculty, research associates, and students hold regular appointments in the departments of Physics, Earth and Planetary Sciences, Chemistry or Electrical Engineering, and all teaching and granting of degrees is done through these departments. Research in the McDonnell Center includes observational and theoretical astrophysics and several areas of planetary science. Using funds provided by gifts to the University from the McDonnell Douglas Aerospace Foundation and the Danforth Foundation, the McDonnell Center supports fellowships for graduate students, brings postdoctoral fellows and distinguished visitors to the campus, and pays for some equipment and key personnel required to enhance the research programs of Center members. A NASA-sponsored program of "innovative research" is also administered by the Center.

II. PERSONNEL AND ACTIVITIES

A. Members of the McDonnell Center

Faculty in the Department of Earth and Planetary Sciences: R. E. Arvidson, G. Crozaz, L. A. Haskin* (Chairman), W. B. McKinnon, J. D. Pasteris, F. A. Podosek, and W. H. Smith*; in the Department of Physics: J. W. Clark, R. Cowsik,† M. W. Friedlander, C. M. Hohenberg, J. I. Katz, J. Klarmann, W.-M. Suen, R. M. Walker (Director of the McDonnell Center), and C. M. Will; and in the Department of Electrical Engineering: B. Abraham-Shrauner. Research Full Professors: (Phys.) W. R. Binns and E. Zinner.

Senior Research Scientists are: (EPS) R. Colson, E. Guinness, B. Jolliff, R. Korotev, M. Sultan and B. Wopenka; (Phys.) T. Bernatowicz; Research Associates: (EPS) J. Brannon, and J. Pier; (Phys.) C. Alexander, P. Dowkontt, T. Ireland, E. Seidel, C. Simon, A. Virag (Visiting Research Associate, Austria), V. Vylet, and G. Zylstra. Technical support: J. Epstein (experiment manager); J. Foote, E. Inazaki, P. Swan, and G. Simberger (engineers); M. Olevitch (computing).

B. Visitors to the Center

Visitors to the Center during 1988-1989 included: C. Alexander (Open University, England), E. Bashkin (Institute of Physical Problems, Russia), R. Bianchi and A. Picchiotti (Univ. of Rome, Italy), I-Ming Chou (USGS, Reston), D. Dominque (Univ. Pittsburgh), K. Gazis (Cal.Tech), H. Graf (Switzerland), E. Economu (University of Chicago), A. El Goresy (Max-Planck-Institut, Heidelberg, W. Germany), B. El Kaliouby (Ain Shams Univ., Egypt), J. Goswami (Physical Research Laboratory, India), A. Guth (MIT), A. Hofmann (MPI, Mainz, W.Germany), M. Hyman and M. Rowe (Texas A&M Univ), G. Kurat (Museum of Natl. History, Austria), M. Lee (Univ. of New Hampshire), H. Lewis (Los Alamos National Laboratory & Dept. of Energy), G. MacPherson (Smithsonian Institute), M. Maurette (Laboratoire Rene Bernas, France), K. Nielsen and R. Stern (Univ. of Texas), D. Page (Penn. State Univ.), A. Polls (Univ. of Barcelona, Spain), C. Prombo (JSC), M. Ristig and G. Singer (Univ. of Köln, West Germany), F. Robert (Univ. of Paris, France), I. Steele (Univ. of Chicago), F. Stadermann (Max-Planck-Institut für Kernphysik, W. Germany), T. Swindle (Univ. of Arizona), R. Taylor (Australian National Univ.), A. Tuzzolino (Univ. of Chicago), S. Weinbruch (Max-Planck-Institut, West Germany), M. Wheelock (Univ. of Albuquerque), B. Whiting (Univ. of N. Carolina), D. Woolum (California State Univ.) K. Young (Chinese Univ. of Hong Kong)

Group Visitors: Austin College; Scientists from Madagascar.

C. Special Invited Talks

In addition to the usual invited colloquia and seminars given by members of the Center, the following is an abbreviated list of special invited talks. **R. Arvidson**, St. Louis Science Center; Adler Planetarium; Gateway CP/M Users Group; American Astronautical Society; American Geophysical Union; Gem and Mineral Society; Univ. Calif.-Berkeley; Venus Geologic Mapping Workshop. **T. Bernatowicz**, University of Missouri-St. Louis; McCrone & Associates, Chicago. **J. Clark**, Argonne National Laboratory; Series of lectures at Mar del Plata, Argentina; University of Minnesota; Institute of Physical Problems, Moscow and Physics Institute of the Georgian Academy of Sciences, Russia; 13th International Workshop on Condensed Matter Theories, Brazil; **L. Haskin**, 20th Anniversary of Apollo 11 Celebration, NASA/JSC, Houston; Penrose Conference on Anorthosites, Laramie. **C. Hohenberg**, Swiss Federal Institute of Technology, Switzerland. **W. McKinnon**, Adler Planetarium, Chicago.; St. Louis Astronomical Society; SIU Edwardsville; AGU Special Session on Planetary Geodesy, San Francisco; AIAA/JPL 2nd International Conference on Solar System Exploration, Pasadena. **J. Pasteris**, USGS, Reston; University of Illinois, Chicago; Gordon Conference on Inorganic Geochemistry. **W. Smith**, American Optical Society, Orlando. **W. Suen**, Quantum Cosmology Workshop, Tufts University; Wormhole and Baby Universe Workshop, Fermilab. **R. Walker**, Southern Illinois University, Edwardsville; NASA Management Presentation-LPI, Houston; LDEF Investigator Working Group Meeting, Washington, DC; Missouri Athletic Club, St. Louis. **C. Will**, 14th Texas Symposium on Relativistic Astrophysics, Dallas; 24th Annual Rencontres de Moriond, France; Distinguished Visitor Lecture, Lincoln Laboratory, MIT.

D. Major Committee Membership and Offices

Major committee membership and offices were held by the following: **B. Abraham-Shrauner**, Editor, *J. Geophysical Research: Space Physics*, **R. Arvidson**, Co-Investigator, Magellan Radar Investigation Group (RADIG); Associate Editor, Cambridge University Press Series in Remote Sensing; Chairman, Magellan Data Products Working Group; Member, Magellan Project Science Group; Member, Advisory Board, NASA Senior Visiting Scientist Program, Jet Propulsion Laboratory; Member, Science Steering Group, Flight Project Support Office, Jet Propulsion Laboratory; Chairman, Planetary Geology Division, Geological Society of America, 1989; Co-Chairman, 1989 Geological Society of America Annual Meeting to be held in St. Louis; Co-Editor, *Geology*; Interdisciplinary Scientist, and member Project Science Group, Mars Observer; Member, Advisory Board, NASA Senior Visiting Scientist Program, Jet Propulsion Laboratory; Member, NASA Land Aircraft Science Management Operations Working Group; Member, SIR-C Science Review Panel; Member, NASA Geodynamics and Geology Planning Committee; Member, Panel on Remote Sensing of the Committee on the Solid-Earth Sciences, Commission on Physical Sciences, Mathematics, and Resources, National Research Council. **J. Clark**, Member, International Advisory Committee for the International Conferences on Recent Progress in Many-Body Theories; Member, Selection Committee for Feenberg Prize in Many-Body Physics; Member, International Advisory Committee for the International Workshops on Condensed Matter Theories; Member, Editorial Board, Plenum Series *Condensed Matter Theories*; Member, Program Committee, Conference on Models of Brain Function, Denmark; Member, Program Committee, 14th International Workshop on Condensed Matter Theories, Italy; **L. Haskin**, NASA Lunar Exploration Science Working for a convincing description of neutron-star cooling and pulsar glitch phenomena. In a second project, refined many-body methods are being used to gain a better understanding of the equations of state of nuclear matter and neutron-star matter and of the elementary excitations of these fundamental systems.

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Clark and coworkers have applied the method of correlated basis functions to establish that polarization effects of the background medium substantially reduce the strength of singlet neutron pairing in the inner-crust region of neutron stars -- a result with important implications for the viability of vortex-pinning models of glitch phenomena in pulsars. The computational effort on equations of state gains urgency from the possibility (indicated by one set of observations) that SN1987A has given birth to a submillisecond pulsar.

2. High Energy Astrophysics

J. Katz developed a phenomenological theory (analogous to mixing length theory) of particle acceleration in turbulent low-density flows. Second-order Fermi acceleration was assumed as the irreversible accelerating process; first-order acceleration is reversible. By making order-of-magnitude (or dimensional) arguments he was able to estimate the rate of particle acceleration. Their energy is drawn from the fluid flow by means of a particle-acceleration-induced-viscosity (PAIV).

He then applied this theory to problems of accretion discs, radial accretion flows, and convective stellar photospheres. It is possible that most of the power released in accretion discs around black holes appears as accelerated particles, chiefly protons. These protons collide with the disc and produce pions which decay to muons and then to electrons. These electrons (typically of 100 MeV energy) radiate synchrotron radiation in the disc's magnetic field, and are capable of explaining both the hard X-rays of Cygnus X-1 and the nonthermal visible and UV continuum of AGN.

3. Astrophysical Plasmas

B. Abraham-Shrauner has been analyzing magnetic fields in plasmas by treating the magnetic field line invariants by one-dimensional Hamiltonian systems. The research has been in collaboration with H. Lewis at Los Alamos National Laboratory. General expressions for magnetic flux surfaces have been given which could be useful in stellarators. Force-free magnetic fields are currently being analyzed. The force-free fields may apply to solar coronal magnetic field structures. The Lie group analysis of the Henon-Heiles equations has been extended to invariants fourth order in the momenta by use of the computer program Mathematica.

4. Gravitation Theory, Cosmology and Relativistic Astrophysics

Will, Seidel and graduate student J. Guinn continued a program of determining the normal modes of oscillation of black holes semi-analytically, using higher-order WKB approximations. Originally applied to the low-order (small n) modes of the Schwarzschild black hole, the method has now been extended by Seidel and S. Iyer (Raman Research Institute) to Kerr black holes, and by Guinn (with B. Schutz and Y. Kojima, Univ. College, Cardiff) to the large n modes of Schwarzschild.

Using the Brans-Dicke theory of gravity, Will and graduate student H. Zaglauer analyzed gravitational radiation damping in the "11 minute" binary system 4U 1820-30, and in the binary pulsar, and studied the constraints that could be placed on the theory. Zaglauer is studying different approaches to an effective 4-dimensional gravitational theory containing light scalar fields that couple to fermions in a way suggested by superstring theory and its low-energy limit. He plans to use experimental results on a possible fifth force and on variability of the fundamental constants to constrain such theories.

Graduate student C. Lincoln is studying gravitational radiation damping and emission in the late stages of evolution of a coalescing binary system of compact objects using the $(\text{post})^{5/2}$-Newtonian equations of motion. He has analyzed the orbit analytically and numerically all the way to the final catastrophic "plunge", and has determined the gravitational waveform and energy flux.

In collaboration with H.-J. Paik (Univ. of Maryland) and B. Mashhoon (Univ. of Missouri), Will continued a study of the feasibility of detecting the "gravitomagnetic field" of the Earth (Lense-Thirring effect) using an orbiting, superconducting three-axis gravity gradiometer. With graduate student A. Wiseman, they are analysing the effects of Newtonian and relativistic orbital perturbations, of the relativistic "dragging of inertial frames", and of instrumental alignment and spacecraft pointing errors, on the ability to detect the tiny gravitomagnetic effect.

A test of the isotropy of the one-way speed of light was carried out at the Jet Propulsion Laboratory, in collaboration with Will, using hydrogen maser frequency standards and optical fiber transmission lines at the Deep Space Network. Preliminary results yielded the limit $\Delta c/c < 3\times10^{-6}$ for an anisotropy which is linear in the Earth's velocity relative to the microwave background.

Suen and K. Young (Chinese University of Hong Kong) proposed that the wave function of the universe is given by the usual path integral formulation, but with the time coordinate real (instead of imaginary in the conventional approach), and with the sum taken over all non-singular Lorentzian (as opposed to Euclidean) 4-geometries. The results suggested that the universe could be modeled as a "leaking" system. In a simple model, the wave function favored an expanding universe with an inflationary phase. The quantum mechanics of such "leaking" systems was found to have potential applications in other areas of physics.

Suen showed that, in the semiclassical theory of gravity, independent of the values of the renormalization parameters, flat spacetime with quantum fields in the Minkowski vacuum is unstable to a certain type of infinitesimal perturbation. Subsequent evolution of these perturbations leads to Planck-scale spacetime curvature in an unacceptably short timescale. For Friedmann (cosmological) spacetimes, infinitesimal perturbations are stable under certain conditions.

Seidel studied perturbations of stellar collapse models in an effort to calculate the gravitational wave emission from black-hole formation. Both odd-parity and even-parity gravitational perturbations were studied, using a May-White stellar collapse code and polytropic equations of state. Results indicate that, while the normal modes of the black hole generally dominate the emission spectrum, some collapse models show significantly damped and distorted waveforms.

Seidel and Suen began a study of the stability and collapse of general relativistic configurations of massive, complex scalar fields, known as "boson stars". Such objects may have formed in the early universe as a result of processes involving exotic particles associated with dark matter, and their collapse may leave a remnant background of gravitational and other radiation.

C. Extraterrestrial Materials

Many extraterrestrial samples consist of primitive materials that were formed at the beginning of the solar system. Their study provides a basic understanding of the processes that occurred subsequent to and during collapse and accretion. Equally important, some extraterrestrial samples contain relatively unaltered pre-solar grains (i.e., interstellar dust) that were formed in different astrophysical settings before the formation of the solar system. The developing study of these pre-solar materials promises to provide new insights into stellar evolution and the formation of the elements (nucleosynthesis). The interstellar materials are identified by their unusual (anomalous) isotopic compositions compared to the bulk of solar system materials. The grains themselves are very small and their study requires sophisticated microanalytic techniques. The development of these techniques and their application to a variety of extraterrestrial materials have been central themes of the Center for many years.

1. Meteorites and Lunar Samples

Virag and Zinner, in collaboration with S. Amari and E. Anders (Univ. of Chicago) made ion microprobe isotopic analyses of various chemical separates from carbonaceous chondrites. One type of separate consists of diamonds of only 15 Å in size. Because these diamonds carry isotopically anomalous Xe (Xe-HL) and N they are believed to be of presolar origin, but a remaining puzzle is their isotopically normal C. The ion probe measurements showed small but significant differences in their C isotopic ratios between different diamond-bearing separates from Allende and Murray indicating enstatite chondrites and Heavilon, a study of enstatite achondrites. These meteorites are the most reduced assemblages of minerals known in the solar system.

Hohenberg and his graduate students have delineated irradiation effects due to pre-compaction exposure of individual meteoritic grains to energetic particles. The quantity of spallation-produced neon is too large to be easily attributed to particle fluxes in the present solar system or those to be found in the primitive solar nebula, given a nominal main-sequence sun. An alternative explanation for these observations is that the sun went through an active (T Tauri) phase that produced particle fluxes several orders of magnitude higher than is characteristic of its later main-sequence activity. This work also provides a detailed study of the distribution of pre-compaction irradiation effects among individual meteorites, identifying common source regoliths (and by inference, common parent bodies).

Solar wind-implanted noble gases from individual microgram lunar grains are being studied by laser extraction and are providing new insight into the solar wind composition. Hohenberg and co-workers are also studying lunar volcanic gases by analyzing lunar glass spheres, presumably volcanic in origin, which contain visible bubbles.

Over the last eight years a number of Center scientists have participated in the field collection of Antarctic meteorites in the program directed by W. Cassidy (Univ. of Pittsburgh). For example, Korotev was a member of the 1988-89 field party that discovered the most recent lunar meteorite found in Antarctica. The 1989/90 field season party includes Crozaz and Walker, who will be returning for the second time to Antarctica.

2. Interplanetary Dust Particles

Studies of stratospheric particles

Center members have pioneered in the study of a new class of extraterrestrial materials, interplanetary dust particles (IDPs) collected in the upper atmosphere by high flying aircraft. Such particles lie in a size range (~ 10 microns), large enough to be collected and studied, but small enough to survive high velocity atmospheric entry.

Measurements made by Center members of the isotopes of hydrogen and noble gases have clearly established the extraterrestrial and "primitive" nature of the "chondritic" subset of stratospheric dust particles. Many of the particles undoubtedly have been released into the interplanetary medium from comets. Ion probe measurements previously showed that a number of the particles have large D enrichments. More recently, Stadermann (graduate student), Walker, and Zinner have used the ion probe to demonstrate that many of the particles are rich in nitrogen, and, further that large enrichments of ^{15}N relative to ^{14}N are found in some particles. This indicates that the material may have been formed in the molecular cloud phase of solar system evolution prior to the collapse of the solar nebula. The infrared spectral features of the particles show similarities with the astronomically determined spectra of protostars and comets. Ion probe measurements of the oxygen isotopic composition of stratospheric dust particles consisting of refractory phases similar to those in Ca-Al-rich inclusions have been made. The excess of ^{16}O found in these dust grains proves their extraterrestrial origin and extends the identification of interplanetary dust particles from the "chondritic" subset to a new class of stratospheric dust particles. Ion probe measurements of D/H ratios in chondritic interplanetary dust particles showed that D excesses are concentrated in small carrier phases. In one particle a sub-μm region has a D/H ratio of at least ten times terrestrial; this highly anomalous sub-grain is probably a relic of interstellar material predating the formation of the solar system.

Work is currently in progress to compare the properties of the collected interplanetary dust with the properties of the dust from Comet Halley that were determined during the recent intensive study of the comet by space missions and earth-based observations. The anhydrous subset of chondritic IDPs is found to have many features in common with the Halley dust; these include similar infrared spectra, the presence of small regions that are rich in the light elements H, C, N, and O, and similar distributions of heavier elements when measured at the 1000 Å scale.

Wopenka uses both micro-Raman spectroscopy and micro-FTIR spectroscopy to study individual interplanetary dust particles (IDPs). These methods are non-destructive and yield complementary information. Whereas micro-FTIR is a quick method for the classification of IDPs into different sub-categories based on the prevalent silicate, Raman spectra yield information on the carbonaceous make-up of IDPs. Both types of vibrational spectra are compared to infrared emission spectra from astronomical objects, and show striking similarities with those from comets and interstellar features.

Space experiments

Following test experiments on Space Shuttle flights 5, 8 and 11, a 2 m^2 large dust-atom collector was launched in April 1984 on the Long Duration Exposure Facility (LDEF). The spacecraft is currently scheduled to be retrieved in December 1989 and returned to earth for laboratory study. Elemental and isotopic analyses will be performed on the deposits produced by the impact of interplanetary dust particles. In addition to giving unique information about interplanetary dust, this experiment serves as a prototype for possible "comet atom return" missions and space station cosmic dust collections. Although originally scheduled for a flight of one year, LDEF will have had a total of 5 1/2 years exposure when returned to earth, providing an unprecedented opportunity to study the long-term effects of the near-earth space environment on spacecraft. In addition to the analysis of the 2m^2 Washington University experiment, Center scientist C. Simon will be involved in characterizing and cataloging impacts over the entire 80 m^2 surface of LDEF. New data on the nature and extent of manmade space debris and the effects of atomic oxygen erosion are expected to result from this work.

Although different classes of IDPs have been identified, their origins (asteroidal, cometary) are still uncertain. An important next step in the study of cosmic dust will be to measure the trajectory in space (velocity and orientation) of individual impacting dust particles and then analyze the isotopic, elemental, molecular, and mineralogical properties of collected fragments and debris. It is anticipated that different types of IDPs will have different classes of orbits corresponding to different origins. In collaboration with J. Simpson and A. Tuzzolino (Univ. of Chicago), Center scientists have developed a new instrument to measure the orbital parameters of individual dust particles and capture them for laboratory analysis. The experiment known as CODE (Walker, PI) was selected for the initial set of attached payloads for space station Freedom. Calibration experiments on a trajectory determination-capture cell prototype were carried out by investigators from Washington University and the University of Chicago at the dust accelerator at the Technical University, Munich, West Germany, earlier this year. Accelerated testing and prototype design will be performed during this next year.

3. Micrometeorites From Polar Sediments

M. Maurette of the University of Paris has recently discovered two important new sources of extraterrestrial materials - particles found in sediments in temporary lakes in the Greenland ice cap and small particles recovered from filtrates of melted Antarctic ice. These particles are intermediate in size between IDPs and meteorites and share some properties of both. The unique microanalytic capabilities of the Center are idealy suited to the study of these particles and Hohenberg, Olinger, and Walker are working closely with Maurette to extract scientific information from these samples. The extraterrestrial origin of individual particles has been established by Ne isotopic measurements made with a sensitive laser-extraction noble gas mass analyzer. Comparison with morphological and compositional data have been used to develop non-destructive criteria for identifying unmelted micrometeorites. The discovery of lunar meteorites in the Antarctic collection, coupled with the growing evidence for meteorites of Martian origin, demonstrates that material from planetary sized objects can be transferred to earth by impacts. Fragments derived from many different solar system objects must be among the virtually unlimited number of micrometeorites found in Polar sediments. Identifying these fragments, and extracting scientific data from them, represent major challenges for the future.

D. Planetary Geology and Geophysics

The Earth and Planetary Remote Sensing Group continued its activities in planetary geology, geological remote sensing, and

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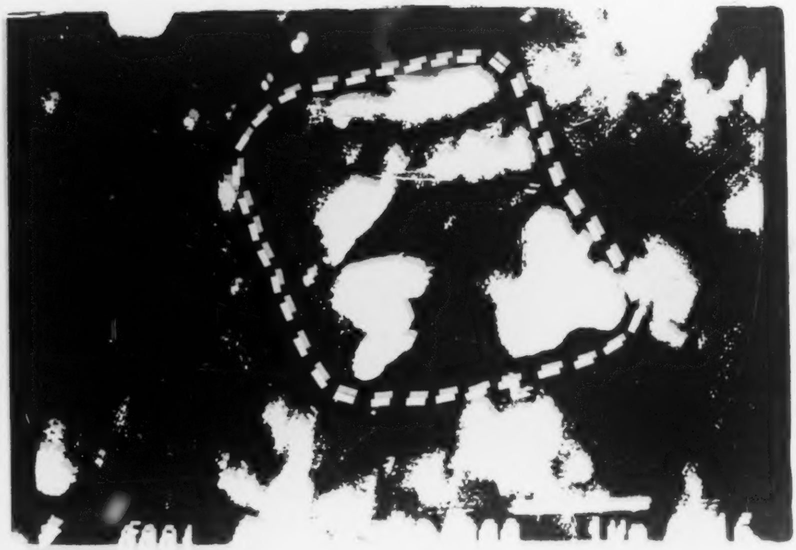

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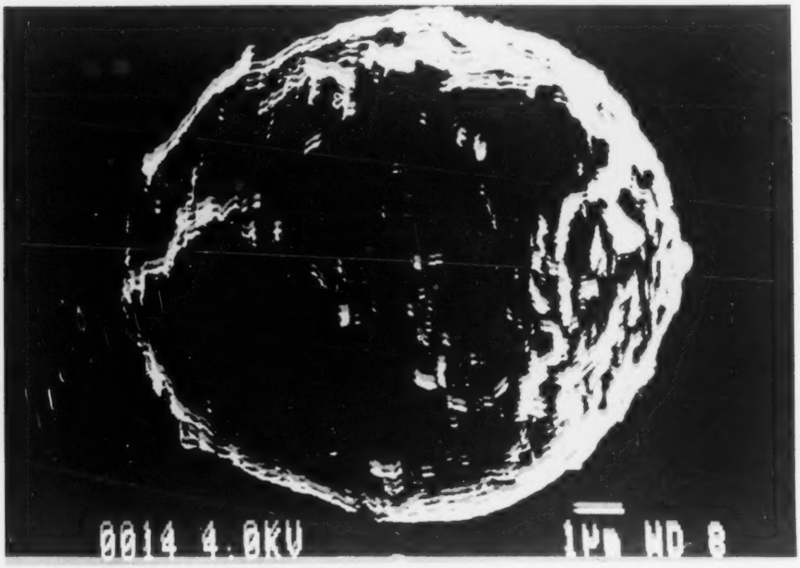
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April 5, 1990

Dr. L. A. Fisk
Associate Administrator for
Space Science and Applications
NASA Headquarters
Washington, DC 20546

Dear Dr. Fisk:

We wish to call your attention to the fact that the planetary science groups at our university are finding it increasingly difficult to work with NASA to carry out their basic mission. Although we can only speak for ourselves, we believe that we comprise a representative spectrum of groups, ranging from those that are large and well established, to those that have entered planetary science relatively recently. In microcosm our experience probably reflects a larger problem affecting the relationship between NASA and university research groups.

We also wish to emphasize that our discontent does not reflect our inability to compete with our peers. On the contrary, we are speaking as individuals who have fared very well in the review processes set up by NASA. The fact that we have succeeded in such competitions but are still faced with growing problems reinforces our view that the difficulties that we see must extend to other university groups.

We recognize and appreciate what you have accomplished in planning and establishing priorities for OSSA and in getting a series of important science missions back on track. At the same time, we see serious problems with NASA funding of basic research programs.

STATEMENT OF THE PROBLEM:

There are several reasons why it has become increasingly difficult for us to make rational plans for the future, or even to continue our normal work with NASA:

a) Funding for our basic research programs has not kept pace with inflation for many years.

b) Although we succeed in peer-reviewed competitions, there is continuing uncertainty on the levels of support that we will actually receive. Initial announced awards are frequently reduced without warning at least once, and sometime more than once, before a real number is given.

c) Even after supposedly final figures are given (frequently after the renewal dates have already passed) the money is held up for long periods of time before it arrives at the university. During this long, uncertain period research groups operate with advanced authorizations from the university, but there is never complete assurance that the money will ultimately arrive.

d) Funding to cover new initiatives (e.g. analysis of LDEF, now that it has returned to earth, or to work on attached payloads selected for Space Station) has not materialized.

Coping with the above conditions has created a situation where we are keenly aware that we are accomplishing less and less productive work as time goes on. We are not working fewer hours; rather our talents and energies are being increasingly dissipated. Some of us are becoming increasingly linked to other funding agencies, taking on other duties (e.g.: service work), doing more administration, and, in general, trying to perform an increasingly complex balancing act to preserve our basic research groups.. Difficult to quantify, but real, is the emotional wear and tear on creative individuals as a consequence of this state of affairs.

It is also demoralizing to see the future being mortgaged. We all know capable young people who could contribute to NASA's goals (some of them our present or former students) who simply cannot break into the system. And why should they? They see what we have to go through and our frustration must communicate itself to the young. Indeed, the advice that some of us give to our students is that although space science is intellectually exciting, they should plan to continue work in the field only if they go into it with their eyes wide open, realizing the increasing difficulties they are likely to face in trying to work with NASA.

Those of us who have been linked to the NASA enterprise for many years believe that the current situation represents a serious deterioration in what has traditionally been a productive partnership between NASA and university scientists.

SOME SUGGESTIONS FOR THE FUTURE:

1. The first thing that needs to be done is to have the agency give higher priority to the goal stated by you in your recent presentation to the Space Science Working Group, "ensure a vital and productive research base." On your list of priorities presented, this was the last. Indeed it seems to us that it not only appeared last on your list but that it has, in fact, been the last of NASA priorities for a long time.

2. The university share of R and A funding should be restored to the levels necessary to maintain excellent research groups. We are not talking about bold new initiatives, simply let good people function at reasonable levels.

3. Do not establish a plethora of new programs to beef up funding to reasonable levels. In most cases this simply results in having to write more proposals and attend more meetings with a consequent loss in productivity for everyone concerned, including those who have to monitor and administer the programs. Take the importance of basic support as a fundamental premise.

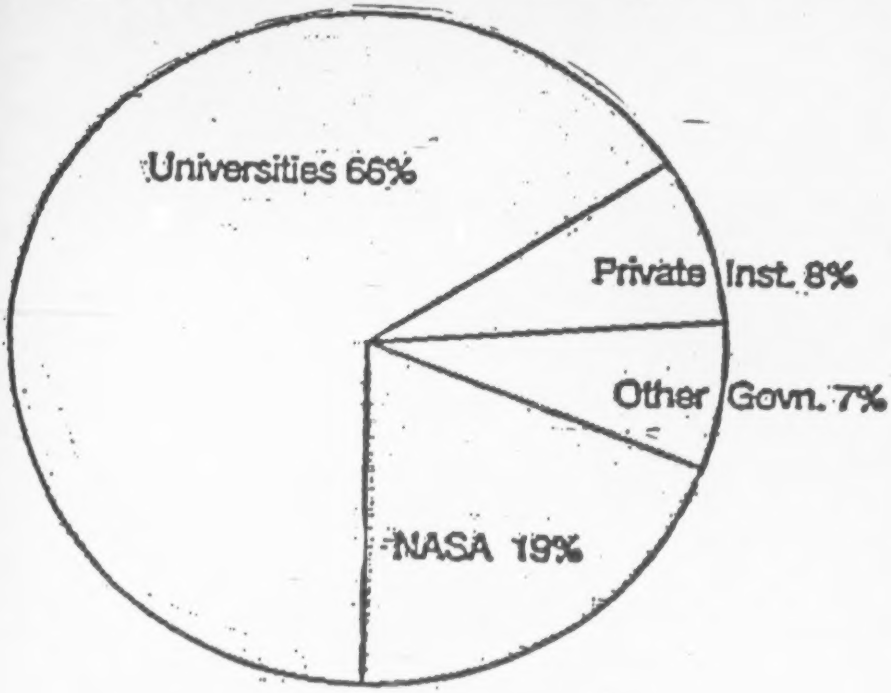
4. Provide a reasonable level of assured support for university R and A. This means stopping the current pernicious practice of imposing sudden "taxes" against programs after funding levels are first announced. Stop using university R and A as an insurance fund for other parts of NASA.

5. Make the accounting system more efficient to eliminate the current long-time delays between starting dates and actual receipt of monies by universities. Other science funding agencies do this, so can NASA.

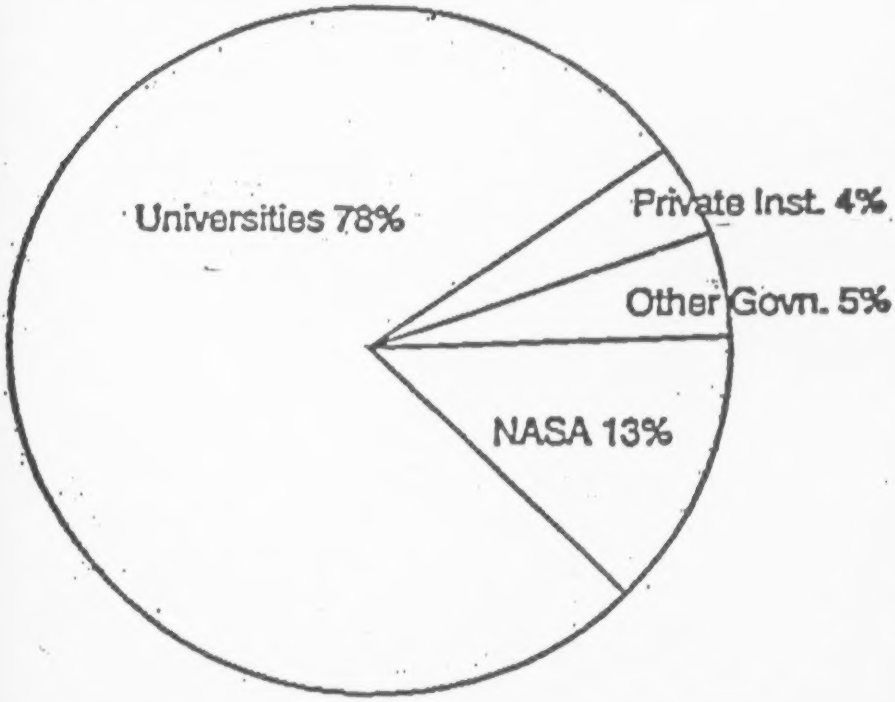
6. Take advantage of the critical mass in space science at institutions like Washington University by supplying institutional funding like the innovative research grant that was formerly awarded to our McDonnell Center.

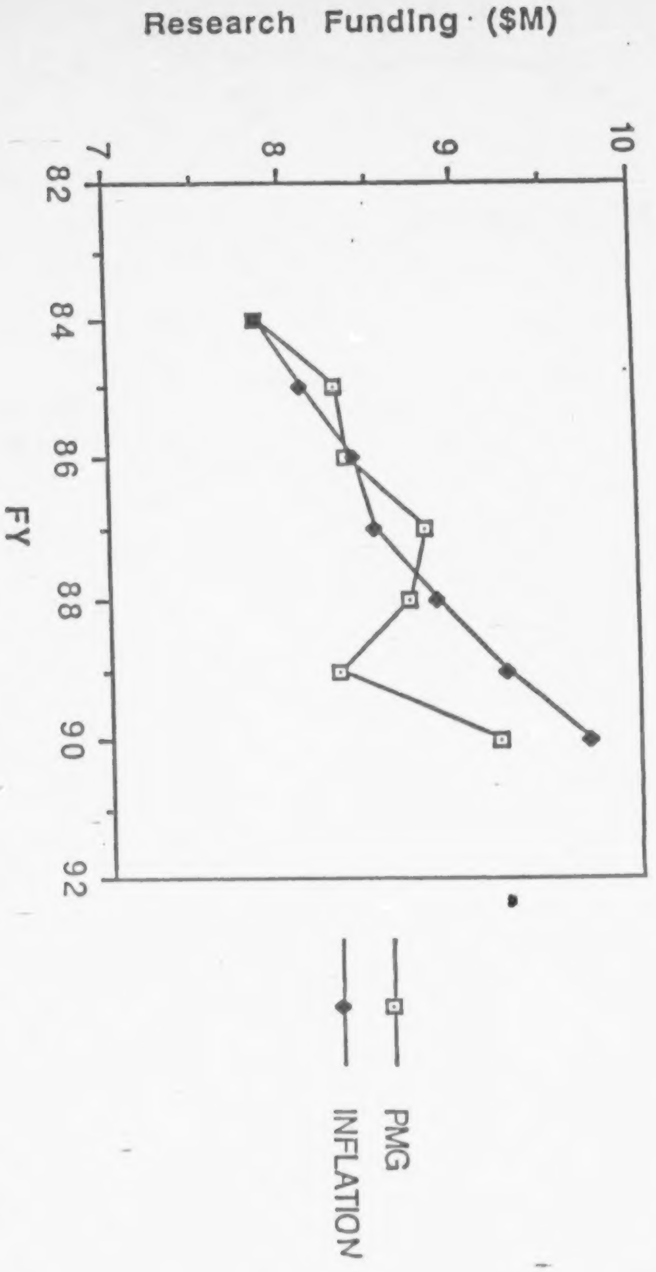
HISTORY
OF
PLANETARY MATERIALS
AND
GEOCHEMISTRY (PM and G)

PM&G, FY90: No. PIs by Institution Type



PM&G, FY90: $K by Institution Type

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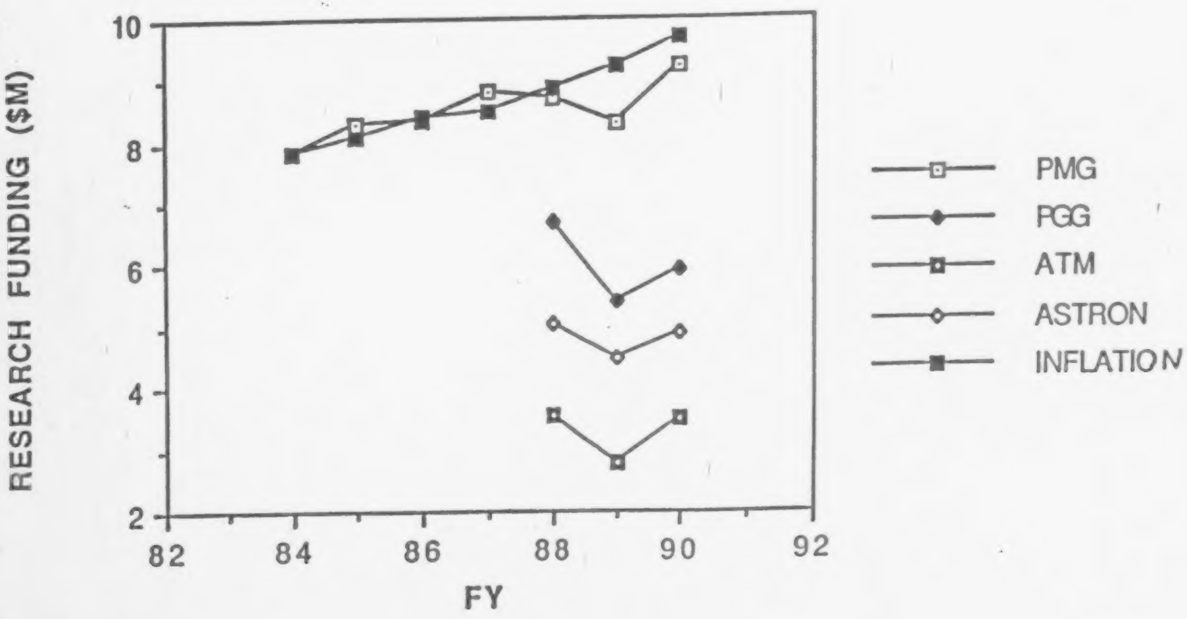
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News *(cont. from p. 371)*

Joint Commission on Rock Properties

A joint commission on Rock Properties for Petroleum Engineers (RPPE) has been established by the International Society of Rock Mechanics and the Society of Petroleum Engineers to set up data banks on the properties of sedimentary rocks encountered during drilling.

Computer-based data banks of complete rock properties will be organized for sandstones (GRESA), shales (ARSHA) and carbonates (CARCA). The commission hopes to access data sources from members of the commission, private companies and the public domain.

Technical issues addressed will include the choice of rock mechanics properties, comparison between in situ and laboratory methods, the addition of geological and geophysical information, the means of collecting and correlating data sources, and the effects of sampling and testing. Participation will initially be tied to data contributions and available data will be accessible to participants on that basis. RPPE will be reporting regularly on the progress of the data banks. Active participation is encouraged by universities, public and private research institutes, and private companies.

For more information on RPPE, or if anyone has information on existing data banks, contact F. J. Santarelli, RPPE Commission President (Europe, Asia and Africa), CST-JF L1, Elf Aquitaine Oil Co., 64018 Pau Cedex, France; tel. 33 59 83 59 52; fax 33 59 83 55 96; or Maurice Dusseault, RPPE Commission Vice President (Americas and Australia), or Najwa Yassir, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada; tel. 519-885-4560; fax 519-746-2543.

University of the Humid Tropics

The creation of a foundation called the University of the Humid Tropics (UNITROP) was announced by Brazilian atmospheric scientist Luiz Carlos Molion at the AGU Chapman Conference on Global Biomass Burning, held March 23 in Williamsburg, Va. The headquarters for UNITROP is in Manaus, Amazonas, Brazil. UNITROP is not a university in a narrow sense, but an institution created and run by scientists with the purpose of understanding Amazonia and developing it socio-economically in harmony with its environment, Molion said.

The scientific objectives of UNITROP are:

- Research: Promote, organize and fund researchers and research in Amazonia, encompassing all branches of science, from social and aboriginal issues to biogeophysical-chemical processes, and leading to an integrated understanding of the tropical forest environment and its transformation.
- Education and training: Promote, organize and finance courses and field research training; grant research fellowships and scholarships at graduate and postgraduate levels. Support educational programs and campaigns for public awareness of the changing environment that originate from other segments of society.
- Preservation: Conserve biomes, ecosystems and areas with high biodiversity or vegetation contrasts that are entrusted to UNITROP by local governments and by other institutions. The reserves will be used for basic research and educational activities.

As an institution UNITROP does not conduct research itself but exists to strengthen the regional research and educational institutions of all Amazonian countries and to help scientists and institutions of other countries establish contact with Amazonian institutions, Molion explained.

On March 12, UNITROP received 100,000 km² (25 million acres) of reserves in different regions of the state of Amazonas; a building in downtown Manaus, with an auditorium that can seat more than 200, and about 100 m² of office space; and significant facilities in the town of Balbina, located 100 km north of Manaus near the Balbina Hydroelectric Power Plant.

Molion said, "We are convinced that the worst problem that Earth will face in the near future is population growth, estimated to double in the next 30 years. Unlike the greenhouse effect and the chlorofluorocarbon buildup, the population growth problem is difficult to resolve because it is mainly related to Third World countries. Well man-

AIP Writing Award

The American Institute of Physics invites entries for its prize in science writing by scientists. May 11, 1990, is the deadline for submitting entries for the Science-Writing Award in Physics and Astronomy for Articles, Booklets or Books Intended for the General Public by Physicists, Astronomers, or Members of AIP Member and Affiliated Societies. AGU is affiliated with AIP.

It is the 21st year for this award for outstanding writing dealing primarily with physics and astronomy to scientists who write about science. Nearly half the awards have been given for writings about geophysics, including four on earthquake prediction and two on the Solar System.

Entries must have been published between May 1, 1989, and April 30, 1990, and must have been written or translated into English. The prize is $3000. Send entries to Public Information Division, American Institute of Physics, 335 East 45th Street, New York, NY 10017, tel. 212-661-9404.

Geophysicists

The National Academy of Sciences gave 15 awards in February to honor outstanding contributions to science; two went to AGU members. Klaus Hasselmann, director of the Max Planck Institute for Meteorology in Hamburg, Federal Republic of Germany, received the $7500 Robertson Memorial Lecture award for his research on ocean waves and ocean modeling and on the stochastic theory of climate. Ho-kwang Mao of the Geophysical Laboratory of the Carnegie Institution of Washington, D.C., received the $10,000 Arthur L. Day Prize and Lectureship for his measurements of fundamental properties of elements and minerals under extreme conditions and for his work using the diamond anvil cell that increased knowledge of planetary interiors.

At the U.S. Geological Survey, three AGU members were among Department of Interior employees honored with the Distinguished Service Award, the department's highest: **Bruce B. Hanshaw** and **Stanley P. Sauer** of the Reston, Va., office, and **L. J. Patrick Muffler** of the Menlo Park, Calif., office. Hanshaw, who was general secretary of the 28th International Geological Congress, held last July in Washington, D.C., was cited for his accomplishments in radioactive waste management, paleoclimatology, and environmental impact analysis. Sauer, currently Delaware River Master, also works with Canadian officials on Great Lakes hydrology, acid rain and other matters of mutual interest; his research is in groundwater contamination and storm-water hydrology. Muffler won the award for contributions to geothermal energy resource assessment and to monitoring volcanic hazards and for his ability to manage scientific programs.

William L. Rambo of USGS, Menlo Park, Calif., was named the Department of Interior's Outstanding Federal Employee With a Disability for 1989. Rambo was left a quadriplegic after his head was hit by an airplane propeller in 1967 while he was salvaging geophysical equipment from the plane. Currently, he is staff geologist for geologic information in the USGS Western Region and chairs the region's interdivisional Earth Science Information Committee.

Benjamin A. Morgan, the USGS Chief Geologist, Reston, Va., was given the Meritorious Presidential Rank Award by the Office of Personnel Management. The award goes to members of the Senior Executive Service for career achievements.

Wayne C. Shanks of USGS, Reston, Va., was named the 1989-1990 Thayer Lindsley Visiting Lecturer by the Society of Economic Geologists. Shanks does research on the genesis and character of seafloor mineral deposits of lead, zinc and copper.

Seven AGU members have been awarded the 1990 National Science Foundation-North Atlantic Treaty Organization Postdoctoral Fellowships in Science. Gary T. Banta of Boston University, Boston, Mass., will study biological oceanography at Odense University, Denmark. Cynthia J. Ebinger of the National Aeronautics and Space Agency will study geophysics at Leeds University, U.K. Anne M. Grunow of Ohio State University, Columbus, will study paleomagnetism at Oxford. David J. Knudsen of Cornell University, Ithaca, N.Y., will go to the Max Planck Institute in Munich, Federal Republic of Germany, to study space physics. Barbara L. Ransom of the University of California, Berkeley, will study geochemistry at the University of Man-

Forum

Planetary Research Loses

The news story "NASA Big Winner in Budget" (Eos, March 6, 1990, p. 315) is misleading, especially since it is printed in a publication that chiefly addresses scientists. One can imagine that the 24% increase in the budget of the National Aeronautics and Space Administration benefits someone, but that certainly does not include working planetary research scientists.

The article says that the budget "contains healthy increases for most activities." Seeing the apparent increase in the Research and Analysis (R&A) line-item for Planetary Exploration (from $70.6 to $89.5 million between Fiscal Year 1990 and FY 1991), one might think that planetary research will suddenly benefit after a decade of erosion and decline. But that is not true.

Approximately $15 million of these funds are really a "slow start" for the Lunar Observer mission, a component of the Human Exploration Initiative. According to William Quaide, who heads the planetary R&A program, the FY 1991 budget represents no increase over the original FY 1990 budget, after correction for modest levels of inflation. R&A is composed of the "Data Analysis" portion of the "Mission Operations and Data Analysis" line plus the "Research & Analysis" line (but minus "Advanced Technology Development," mission planning, and "slow starts").

The history of basic planetary research has been one of continuing decline, despite strong recommendations by various NASA and outside advisory groups that the trend be reversed. Quaide estimated in 1987 (in materials distributed to the Planetary Astronomy Management Operations Working Group, which I then chaired) that planetary R&A had declined by about 30% since the beginning of the decade. $10 million more was lost in FY 1988. That was partly addressed by moving anniversary dates of research grants, but with serious attendant problems (see below). A few months ago, the modest level of proposed FY 1990 funding was seriously eroded again due to three factors: cuts mandated by the Gramm-Rudman-Hollings act, reallocation of funds for President Bush's war on drugs, and dipping into R&A funds by the director of the Solar System Exploration Program in response to some mission overruns.

These cuts have meant the further reduction in research and loss of young planetary researchers, who have had to change career objectives. Just a few among the many research efforts that were stopped or not funded in the last few months are:

- The highly touted interdisciplinary program to study the origins of solar systems. More than 100 proposals were submitted and evaluated for funding in FY 1990, and then the program was zeroed out. As has happened so often in the past, it is now promised that some funds will be available for this effort in FY 1991; but with no real increase in the overall R&A funds, it means that the money will have to be taken out of other ongoing research efforts.
- Despite the enormous success of Voyager's Neptune encounter, there are no funds available for the American planetary science community to participate in analysis of these data. NASA plans in 1987 showed that a $5-million-per-year Neptune Data Analysis Program would commence in FY 1990. Instead, there were no dollars at all, so only actual members of the Voyager science teams have had FY 1990 funding. As for FY 1991, it is my understanding that $4 million are included in the "Mission Operations" line item, but that when the official NASA Research Announcement hits the streets, it may be for only $2.5 million.
- Despite NASA's great interest in human exploration of Mars, the "Mars Surface and Atmosphere Through Time" research program was abruptly canceled a few months ago, just after successful proposers had been informed that their proposals were accepted.

There are problems that go beyond the budgetary numbers. NASA's "solution" to the $10 million hit 2 years ago was to move up many "anniversary dates" by several months, often to the very beginning of the Fiscal Year. But several bureaucratic factors have rendered this a disaster rather than a solution. Perhaps the most serious of them is constraints placed on NASA by the Office of Management and Budget, by which NASA's funds are allocated on a quarterly basis only. Although I understand that the action was in response to a congressional mandate designed to control NASA's Space Station costs, it is coming out of the hides of research scientists. Certain funds had to be spent immediately in the fiscal year; for example, Galileo was launched during the first month of FY 1990. So it turned out that there was very little money left for research.

I talked with many planetary research scientists at the Lunar and Planetary Science Conference in March who complained that *they still do not have* funds for research programs that were to have begun last autumn. It should be remembered that a larger fraction of planetary research funds goes directly to salary support than is the case in many other fields of science (after all, few universities offer many courses in planetary science, so more than half of senior planetary researchers are on "soft money" for 100% of their salaries). Few institutions can float salaries for 6 months, so many research efforts have been badly damaged. All resilience had already been bled out of planetary research programs during the past decade of declining budgets.

In passing, I should note that planetary missions do not provide as many opportunities for sustaining planetary researchers as they used to. Due to policy decisions made during the 1980s, fewer scientists are involved in recently approved planetary missions than was customary in the 1970s, and their involvement is often limited to trips and participation in meetings. As a member of the Galileo imaging team, I can report that funding constraints loom large even within this supposedly well-funded mission. Although I cannot believe it will ultimately turn out this way, recent Galileo Project memos suggest that we will be unable to accomplish the long-advertised "Earth movie" during this December's fly-by of Earth; also scan-platform calibration sequences necessary for next year's first-ever fly-by of an asteroid have been canceled because of budget cuts.

No doubt NASA's big budget increases are going somewhere. It is even possible that planetary science will ultimately benefit from some of them, although few of my colleagues expect that to be true. But it is absolutely true that the basic research community finds itself more pinched than ever before and morale is very low. It is a shame that this should be the case just months after the conclusion of Voyager's historic expedition, in the year when Magellan will arrive at Venus, and as Galileo breaks new ground in the scientific understanding of Venus and the Moon. Without an infrastructure of enthusiastic students and young scientists, refurbished laboratories and observatories, modern instruments and computers, and a broad-based program of scientific inquiry, NASA will be ill-prepared to accomplish the robotic and piloted missions that are planned for the early years of the next century.

Clark R. Chapman
Planetary Science Institute
Tucson, Ariz.

AGU

AGU Membership Applications

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Leo A. Maslow (), Vladimir A. Osherovich (SM), Leonard C. Rosen (A), Miguel F. Sastre (O), Rich D. Saylor (A), James Lawrence Stair (), Yan Ming Wang (G).

Student Members

Leslie Colby Bender, III (O), Christopher F. Clarke (P), L. A. Doglia (SM), James D.

R&A in Space Physics

The recent letter from Clark Chapman in the April 3, 1990, issue of *Eos* (p. 376), concerning planetary research supported by the National Aeronautics and Space Administration struck a resonance that warrants airing in view of the analogous situation that prevails in Space Physics research. The situation for Research and Analysis (R&A) and Data Analysis programs in Space Physics has a more complicated history in view of the fact that only recently has the Space Physics discipline been given its own division within NASA (with thanks to the particular efforts of Lennard Fisk and Stanley Shawhan). For many years, Space Physics research was spread among several divisions at NASA headquarters. Now, magnetospheric, cosmic ray and heliospheric, upper atmospheric and ionospheric, and solar physics have been gathered together under the umbrella of the Space Physics division. It was hoped that this highly desired and much heralded merger would give these related scientific subdisciplines greater coherence and greater visibility, and hence make them better able to compete for needed resources. However, even in the years before the *Challenger* disaster, it became clear that the issue is no longer simply one of competition between the research divisions within NASA. Across all disciplines, the struggle for survival by research groups outside of NASA centers has become crippling.

The crisis is perhaps best appreciated when one considers the overwhelming response to NRA's and other announcements of opportunity. These "proposal pressures" are a measure of the extent to which the community is crying out for resources to carry on research programs of substance. In every case, the oversubscription is such that headquarters' personnel, in concert with peer review panels, must decide either to fund a few proposals at close to their requested levels (so that at least a few groups stay healthy), or a greater fraction at a low level (so that more can hang on). Proposals now can pass peer review with flying colors and be turned down for programmatic and/or budgetary reasons. While this has happened in the past, it was never so common. To compound the problem, add postponed start dates, increasing overheads, the fact that few universities have academic programs in Space Physics (so that most of the salary support for the field depends on the grant process), and increasing competition for space physics funds from other communities (such as the fusion research community) who traditionally found support from other sources. The stress and low morale that have resulted from this continuing situation are problems that have been raised at virtually every National Academy of Sciences committee meeting that I have attended in the last 6 years.

It needs to be emphasized that although increased proposal pressure appears to be desired by administrators today, this phenomenon has had some very deleterious effects on the field. An ever greater proportion of time is spent writing proposals rather than engaged in scientific pursuits. The writing of proposals is a hidden overhead for the researcher who has only a fixed amount of time both to do the science and seek support for it. The average grant size is declining, but researchers are still expected to make the same significant progress as they ever did, whether or not they were able to hire graduate students or postdoctoral assistants. The greater proposal pressure decreases the chance of any one proposal being funded, and makes the multiyear support needed for most projects, especially those involving thesis research, less stable. When fewer than 25% of proposals are being funded, the discriminators between the worthy proposals are weaker, and random fluctuations in the review and decision processes become more important. Understandably, peer reviewers feel the burden of yet another nonresearch task when asked to contribute more and more time to this endeavor. As a result of the extra effort now required to work within the system, and the uncertainties of funding, researchers worry about taking on new students. Meanwhile; the scientific personnel for the approved space programs of the mid and late 1990s seek training today.

The recently issued NRA for guest investigators for analysis of data from recent spacecraft does make up for the resources lost to experimental and data analysis groups when a spacecraft reenters or completes its mission. In fact, much of the data returned is being lost, for all practical purposes, because the funds to the experimenters are being cut off before the data have been completely archived. The Space Physics Theory program is already "sold out" through 1992. Both suborbital programs in solar physics and cosmic and heliospheric physics, and the cosmic physics theory and data analysis program are fully subscribed through 1991. The once-inspired "vitality package" that was supposed to get the community past a low point in 1987 now looks to be necessary every year.

NASA's budget may be going up, as the *Eos* article that inspired Chapman's letter said ("NASA Big Winner in Budget," March 6, 1990, p. 315), but the state of the community that is ultimately the end product of NASA's activities continues to decline. The increased funding is not trickling down to the research scientist. As stressed by Clark Chapman, we must not give the outside world the erroneous impression that the increasing NASA budget means a healthy and happy space science research community. It is not clear how this situation can be remedied, except by a reordering of priorities and a reevaluation of both the state of the community and the funding process by the agency. NAS and NASA committees, together with individuals who are similarly concerned, should make their voices heard, in effect, to "cast their vote" for change.

Janet G. Luhmann
Institute of Geophysics and Planetary Physics
University of California, Los Angeles

Defining TTD

In response to the Forum article "Dc
ate Time Rising Sharply: How long sh
take?" by William Glen (March 27, 199
contend that Glen (and the authors of
he cites) may be overlooking a possible
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ADVANCED ANALYTICAL FACILITIES

REPORT OF THE PLANETARY MATERIALS AND GEOCHEMISTRY WORKING GROUP

LPI Technical Report Number 88-11
LUNAR AND PLANETARY INSTITUTE 3303 NASA ROAD 1 HOUSTON, TEXAS 77058

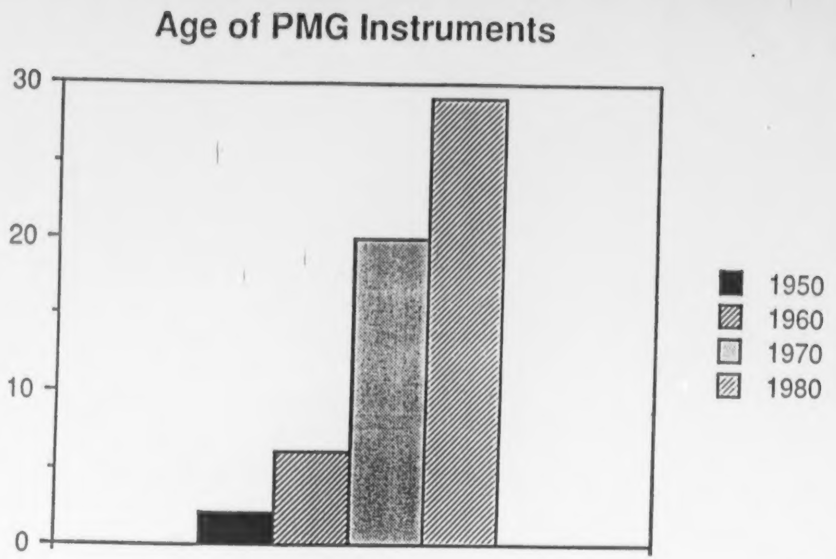

Figure 1

This histogram shows the decade of acquisition of instruments utilized by PI's in the Planetary Materials and Geochemistry (PMG) Program for six U.S. institutions surveyed. The ordinate is number of instruments. Instruments acquired in the 1980s are regarded as state-of-the-art. Approximately 1/2 of the instruments utilized are of pre-1980 vintage, with some going back into the 1950s.

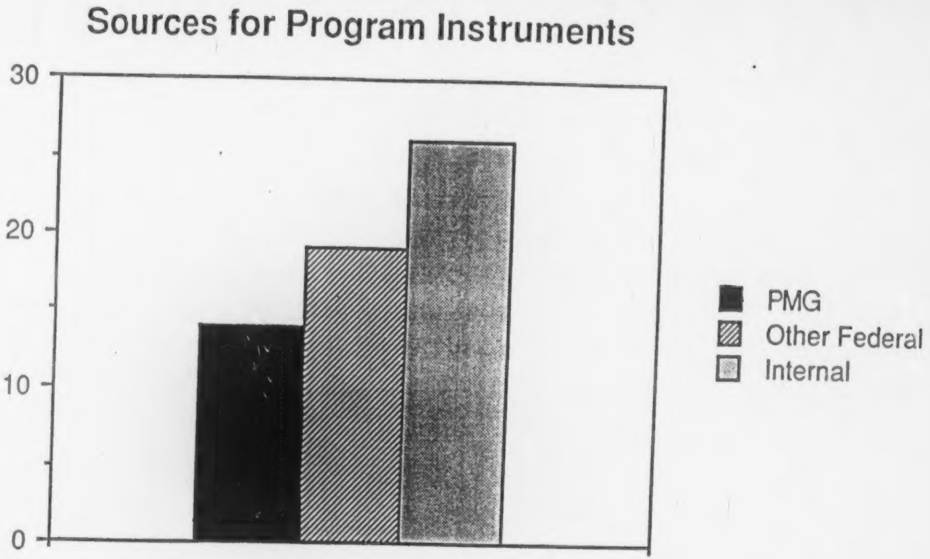

Figure 2

This histogram shows the primary source of funding for the acquisition of the instruments used by the PMG Program institutions surveyed. The ordinate refers to number of instruments. The NSF is the most common source of other federal funding. Only a fraction of the instruments utilized were funded by PMG or previous NASA extraterrestrial materials analysis programs, including the Apollo program.

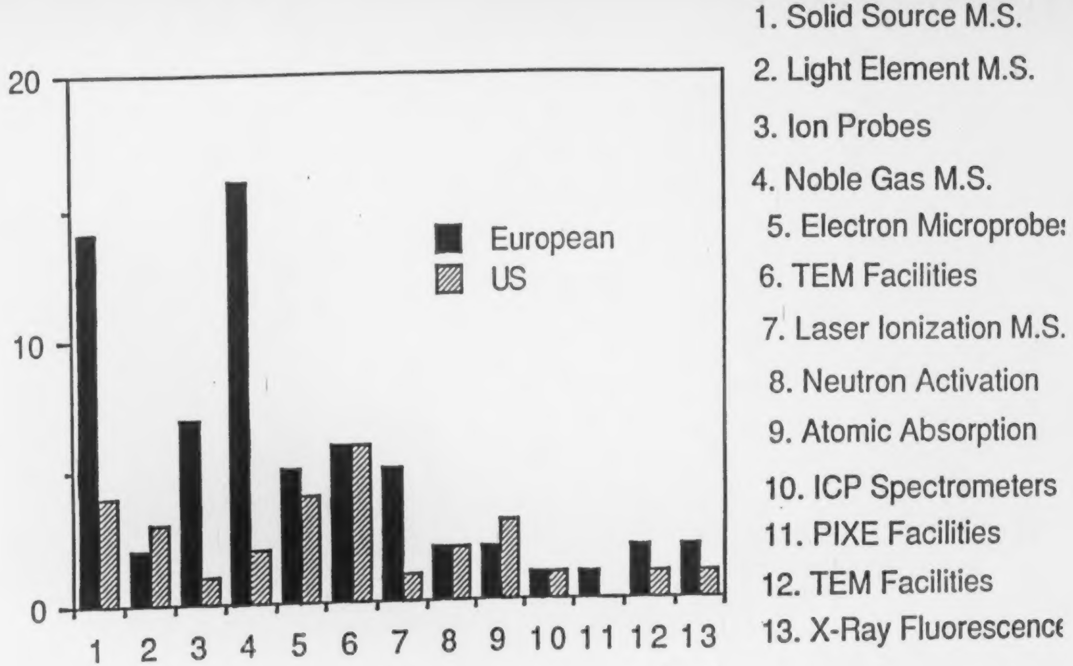

Figure 4

For 13 categories of instruments surveyed, the histogram compares the number of state-of-the-art instruments in six major foreign geochemical analysis laboratories with the 6 U.S. institutions surveyed. In essentially every category foreign laboratories are better equipped.

CURRICULUM VITAE

ROBERT M. WALKER

Born:	February 6, 1929, Philadelphia, Pennsylvania
Education:	Union College, Schenectady, NY, B.S., Physics 1950 Yale University, New Haven, CN, M.S., Physics, 1951 Yale University, New Haven, CN, Ph.D., Physics, 1954
Employment:	1954-1966: Research Physicist, General Electric Laboratory, Schenectady, NY 1958: Adjunct Professor, Metallurgy Dept.; Physics Dept. 1965-1966 Rensselaer Polytechnic Institute, Troy, NY, 1962-1963: National Science Foundation Senior Post-Doctoral Fellow and Visiting Professor, University of Paris 1966-1975: McDonnell Professor of Physics and Director, Laboratory for Space Physics, Washington University, St. Louis, MO. Jan. 1972-June 1972: Visiting Professor of Physics and Geology, California Institute of Technology, Pasadena, California May 1975-Aug. 1975: Visiting Scientist, Laboratoire René Bernas, University of Paris, Orsay, France 1975- : McDonnell Professor of Physics and Director, McDonnell Center for the Space Sciences, Washington University, St.Louis, MO Dec. 1981-Feb. 1981: Visiting Scientist, Physical Research Laboratory, Ahmedabad, India Mar. 1981-Aug. 1981: Visiting Scientist, Institut d'Astrophysique, Paris, France Laboratoire René Bernas, Orsay, France
Scientific Work:	Has given numerous invited and contributed talks and has published 186 papers and one book in several fields including nuclear physics, solid state physics, geochronology, and space physics. Is best known for fundamental investigations of radiation effects in metals, the discovery of etched track detectors, and the application of these detectors to a variety of scientific and practical problems including the development of the fission-track dating method, the discovery of extremely heavy

cosmic rays, and the record of energetic particles in space as recorded in extraterrestrial materials. He has also conducted research in thermoluminescence and its application to art authentication and archaeological dating. Major current interests include the laboratory study of extraterrestrial dust particles collected in the upper atmosphere and the location and identification of preserved interstellar dust in primitive meteorites. As part of his continuing interest in the study of meteorites, he was a member of the 1984-85 expedition to collect meteorites in Antarctica.

Professional Societies:

Fellow: American Physical Society
Meteoritical Society
American Association for Advancement of Science
American Geophysical Union

Member: American Astronomical Society
International Astronomical Union Commission 17, 1976-

Major Committees:

National Academy of Sciences Ad-Hoc Committee on "Engineering Problems of the Developing Countries", 1961.
NASA Scientific Advisory Committee on Exploration of the Moon, Santa Cruz, 1967.
Member, Lunar Sample Analysis Planning Team, NASA, 1968-1970.
Member, University Organization Committee for Space Research, 1969.
Member, Board of Directors, University Space Research Association, 1969-1971.
Member, Lunar Sample Review Board, 1970-1972.
Member, Lunar Science Institute Advisory Committee, 1972-1976.
Member, Board on Science and Technology for International Development, National Academy of Sciences, 1974-1977.
Member, Temporary Nominating Group in Planetary Sciences, National Academy of Sciences, 1973-1975.
Chairman, VITA Committee on Technical Projects, 1975-1980.
Member, Committee on Planetary and Lunar Exploration, National Academy of Sciences, 1977-1980.
Member, Board of Directors, VITA
Member, Space Science Board, National Academy of Sciences, 1979-1982.
Sigma Xi National Lecturer - 1984-1985.
Member, Organizing Committee COSPAR-IAU, Marseille, France, 1984
Member, SESAC Task Force on Scientific Uses of Space Station, 1985-86.
Member, Antarctic Meteorite Working Group, 1985-1988.
Member, NASA Planetary Geoscience Strategy Committee, 1986.
Member, European Science Foundation (ESF) Scientific Organization Committee (SOC), 1989.
Chairman, Meteorite Working Group, 1990-1992.

Honors and Awards:

NSF Senior Post-Doctoral Fellowship, 1962.
Co-winner, American Nuclear Society Annual Award, 1964.
Yale Engineering Association Annual Award for Contributions to Basic and Applied Science, 1966.
Honorary Doctor of Science, Union College, 1967.
Two Industrial Research Magazine IR 100 New Product Awards, for products he helped develop, 1964 and 1965.

NASA Exceptional Scientific Achievement Award, 1970.
U.S. Atomic Energy Commission's E.O. Lawrence Memorial Award, 1971.
Member, National Academy of Sciences, 1973.
Docteur Honoris Causa, University of Clermont-Ferrand, Aubière, France, 1975.
Antarctic Service Medal, National Science Foundation, 1985.

General: One of the founders and first president, Volunteers in Technical Assistance (VITA), currently serving on the Board of Directors. VITA is a volunteer organization of over 7,000 engineers and scientists who work on practical problems of technical development for third world countries.

Patents: U.S.: 3,303,085
3,335,278
3,415,993
3,564,250
British: 1,042,602 (U.S. counterpart, 3,303,085)

Mr. HAYES. Let me get a time check. All right we have a few minutes left that we can devote to questions. I will yield that opportunity to the home team, the gentleman from Missouri, Mr. Buechner.

Mr. BUECHNER. Dr. Israel or Dr. Walker, either one of you, I think you really pointed out a problem that when we do have the money internally in the NASA budget and then there are shrinkages in any other part of it, that you become the natural repository of the fist coming into your little cash box, is that right?

Dr. WALKER. That is right. We are the insurance part.

Mr. BUECHNER. I am wondering, do you have any suggestions on a way to—you are one of the winners and obviously there are not that many winners. How many universities are there? We saw an earlier slide by Jim Rose, but how many universities have gotten what you have gotten, do you know?

Mr. VOLKMER. Quite a few, a lot of them.

Dr. WALKER. How many university groups—

Mr. BUECHNER. Have been able to be a part of the grant program that you have been involved in.

Dr. WALKER. Oh, well many of course, they are scattered all across the whole country.

Mr. BUECHNER. Is there any sort of lobbying effort by you all to work Congress on this aspect?

Dr. WALKER. Yeah, there is, the former chairman of the lobbying group is sitting at my right hand. I will let him talk.

Dr. ISRAEL. The Space Science Working Group, which is part of the Association of American Universities, has tried to do that. I think scientists and university professors in general are notoriously bad at keeping communication up with you gentlemen in Washington, but there is a group that has tried to keep contact at the Association for American Universities and we have tried to keep this pressure up.

But you are quite right, Mr. Buechner, the—when there is a Gramm-Rudman cutback to NASA budgets or a tax for the war on drugs to NASA budgets, NASA is faced with the fact that the flight programs often have naturally imposed flight deadlines, and if they try to do an across-the-board even split, then a particular flight program will miss its deadline which is terribly expensive and so that program is insulated and instead, the basic, ongoing research gets a disproportionate part of the cut. And I think that is the serious problem and it is a problem that I think goes back to what Professor Walker was saying, making sure that there is enough contingency in the flight programs when they get started, so that if things happen, either internal to flight programs, technical problems, or externally imposed budget problems at NASA, the flight programs can take their share without letting the basic research programs take a disproportionate share of those cuts.

Mr. VOLKMER. Thank you. I yield back, Mr. Chairman.

Mr. HAYES. Well as a consequence of the passage of time and circumstances over which I am afraid we have no control, I will thank—

Mr. VOLKMER. I have one more thing.

Mr. HAYES. Oh, he wants to jump back in now, see.

Mr. **Volkmer**. I want to jump back in real fast. No, no, you can close it, but I just want to tell Dr. Walker that I have thoroughly reviewed your testimony last night and it raised concerns in my mind. In my opinion, I think it would be appropriate for us to take that testimony back to Washington and submit it to NASA and request their explanation. I am quite concerned because if what you are saying is actually happening not only to you but to other universities and to our total research, then it is something that I feel partially responsible for because I can remember back when we started the Space Station, which is the big boy on the block right now. And when we started that, we made a commitment, some of us on the committee, that the same thing that happened—or that thing that happened during the Shuttle, when the Shuttle had its cost overrun, definitely was not going to happen to our research program, our science programs in NASA when we got into the Station. But now you are telling me that it looks like that may be starting to happen.

And with that, I just wanted to make that statement to you and let you know that I for one am committed to getting that money back in and make sure the money is spent properly for research if we have to fence off the money from the rest of the Shuttle operations and Space Station and everything else, then I think it may be appropriate to do that. So I just wanted to let you know that we will be doing that and we will see what NASA has to say.

Dr. **Walker**. Thank you.

Mr. **Hayes**. I want to thank all of our panelists and thank those in the audience for their attention, and in the words of that eminent scientist, Judge Wapner, this hearing is concluded.

[Whereupon, at 10:49 a.m., the Subcommittee was adjourned.]

APPENDIX

Material requested for the record by Congressman Volkmer during the July 23, 1990, hearing.

The decline in planetary research funding has been significant during fiscal years 1989 and 1990. This decline is principally due to unique circumstances.

The abrupt decline of funding in fiscal year 1989 was the direct consequence of Congressional direction to reduce planetary program funding by $10 million. It is extremely difficult if not impossible to reduce planned expenditures for planetary spacecraft development where the pace and schedule of development is critical to the delivery of the spacecraft on time for launch during dynamically constrained, infrequent opportunities. General funding reductions for planetary programs, therefore, translate into disproportionate reductions for Research and Analysis programs. Such was the case in fiscal year 1989.

The problems in FY 1990 have been heightened by a combination of factors that hopefully we will not have to cope with simultaneously in future years. The factors include: initiation of the fiscal year under a Continuing Resolution, across-the-board reductions to meet Gramm-Rudman targets and to fund the Federal war-on-drugs effort, a cap on total research and development spending obligations prior to April 1, 1990. I am hopeful that the President's budget proposal for FY 1991 and budgets for future years will enable us to redress many of the problems space scientists have experienced in 1990.

While these explanations underscore the fact that the reductions in planetary research funding were not planned, they were nonetheless real. Consequently, the concerns expressed regarding NASA's commitment to support the universities and university scientists, particularly in the area of planetary science, are understandable. NASA's commitment remains firm. The universities play a critical role in the United States space program, both as principal sites of research and as the sources of the next generation of trained professionals to meet NASA's and the nation's needs.

In general, NASA's recent support for universities has been substantial. For example, total NASA funding to United States universities was approximately $465 million in fiscal year 1989. NASA will fund at least 500 graduate student fellowships under the Graduate Student Researchers Program in 1990, and several new related efforts such as a fellowship program for students seeking advanced degrees relevant to Earth system science are being initiated. Furthermore, NASA expects to expand several university programs such as the University Space Engineering Research Centers sponsored by the Office of Aeronautics, Exploration and Technology, the Joint Venture in Education (JOVE) program sponsored by the Office of Space Science and Applications, and the National Space Grant College and Fellowship program.

In looking ahead, with specific attention to the planetary sciences, the President's strong fiscal year 1991 budget would ensure that planetary science funding would recover from the setbacks of 1989 and 1990. Moreover, in its current planning for 1992 and beyond, NASA is examining opportunities for additional initiatives that would strengthen university space science programs even more.

NASA continues to strive for an adequate balance between Research and Analysis (R&A) and scheduled requirements for spacecraft. While augmentations or "fixes" have been made to NASA's budget requests in recent years to assure a healthy level of support for research and the "individual investigator," R&A budgets have been especially vulnerable to general reductions imposed to meet deficit targets.

The "choice" to fund spacecraft development at the expense of Research and Analysis is never an easy one. To ensure the availability of funds needed to support a vital research program, NASA will continue to aggressively seek the funding required to support a balanced and robust agency budget with adequate program reserves for flight project contingencies.

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